His Majesty's Government of Nepal
Department of Irrigation
Groundwater Resources Development Project

Reassessment of the Groundwater Development Strategy for Irrigation in the Terai

Inception Report

March 1993

Groundwater Development Consultants Ltd
Cambridge, United Kingdom

in association with

Hunting Technical Services Ltd
Hemel Hempstead, United Kingdom
EAST Consult (P) Ltd
Kathmandu, Nepal

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SUMMARY

1. Preliminary data collection and assessment and field reconnaissance work is complete as are initial discussions with most of the concerned agencies.

2. The remaining field work will focus on an extensive survey of about 100 shallow tubewells (STWs) across the main and inner Terai. This should yield valuable data on technical, sociological and agricultural aspects of STW operators' perceptions, achievements and constraints; focussing on what we still view as low well utilisation and associated production/ income levels.

3. More specific information on STW design, drilling and development is being obtained through a programme of drilling contractor interviews.

4. Groundwater studies will include review of DTW design, construction and monitoring data to identify any constraints to trouble-free operation, and to address reported falls in DTW specific capacity, and sand ingress.

5. There is a special need to obtain monitoring data on pressure response of the deep, artesian pumped aquifer; we request urgent BLGWP help with this.

6. We will review the 1987 lithological and aquifer development classifications, and derived development mapping, against lithological and test data from post-1987 deep boreholes. Previous optimisation of DTW design will be revised on the basis of 1993 cost data and any new aquifer data. Subject to the availability of sufficient historic data on head changes in the deep artesian aquifer, we will review the approach to pumping flowing DTWs.

7. The UNDP/GWRDB shallow aquifer mapping of the Terai should provide a sound basis for review of the shallow zone lithological and aquifer development classification, and appropriate revisions of the shallow aquifer development zone mapping for the whole Study Area except Surkhet. Scattered anomalies exist and will be investigated; specific data gaps occur in Dang and Surkhet which will be covered with a shallow well survey and field checks.

8. We have proposed a brief study of drainage needs in low lands near free flowing artesian wells, and a brief overview of women's involvement in Terai farms. These are new tasks and we request an expatriate drainage engineer (0.75 MM) and a Nepali women's development specialist (0.5 MM) to effect them.

9. We have proposed a short study tour to Bangladesh early in May to enable our DOI counterparts to learn of groundwater development progress there; particularly with regard to STW technology and private sector development, the operation and design of DTWs and associated distribution works, and progress with mid-capacity wells using both forced and suction mode pump installations.

10. We also wish to visit the World Bank Mission in Delhi to discuss progress and developments with IDA groundwater development projects in India.

11. We see no difficulty in submitting the Draft Final Report on time. We hope that there will be wide opportunities to discuss our ideas on strategy development with DOI and associated agencies/ policy makers. Such feed-back will strengthen the "how to" aspects of development in our Final Report.

12. As part of this process we suggest August 1 as the start date for a one or two day strategy development workshop to address a discussion paper we will submit along with the 2nd quarterly report in mid-July. We hope that DOI, ADBN, NEA, DOA, the World Bank and any other agencies which DOI might suggest will participate, and wish to discuss the actual dates as soon as possible.

13. We gladly acknowledge the DOI's strong support during the Study to date.

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CHAPTER 1

INTRODUCTION

1.1 General

This document is the Inception Report as required in Item 18 of the Terms of Reference given in Appendix A to the Contract for Consulting Services between the Department of Irrigation (DOI) of His Majesty's Government of Nepal, and Groundwater Development Consultants (GDC) dated 25 December 1992, and reproduced as Appendix I.

For this assignment, GDC are associating with Hunting Technical Services Ltd (HTS) for agronomic and economic aspects and with EAST Consult (P) Ltd (EAST) who are providing local consultant inputs to all disciplines.

1.2 Study Area and Objectives

The Study Area covers the whole of the main Nepal Terai which borders with India; this comprises 18 districts, all of which include both Terai land (typically about 75%) and part Siwalik Hill land. The Study Area also covers the 'inner Terai' areas in the Dang, Deukhuri and Chitwan valleys within the Siwaliks together with the small valley surrounding Surkhet to the north of Bardia District. The locations of the districts and the distribution of Terai and Siwalik land are shown on Figure 1.1.

The overall objective of the study is to determine the most suitable strategy for sustainable groundwater irrigation development in the main Terai and inner Terai valleys; this will be achieved by examining the relative technical and non-technical merits of deep and shallow groundwater irrigation systems, assessing the extent and nature of groundwater development zones and agricultural land, addressing the policy issues and practical experience associated with groundwater development (in particular the scope for farmer participation, private sector ownership and implementation/ management/ operation and maintenance capability) and the balance between shallow and deep groundwater development in the shorter and longer terms.

1.3 Progress

The Study started with the arrival of the Study Coordinator in Nepal on 18 January 1993. Since then, an office has been established near EAST Consult's office in Lazimpat, and all key personnel have been mobilised to plan the Study scope in more detail.

The main field reconnaissance work has been completed during this period, including a series of two missions to visit all districts from Chitwan in the Central Region, through the three Western Region districts and three Mid Western districts, terminating in the Surkhet valley. A third mission has also been mounted to see groundwater irrigation related activities in the Birganj area in the main Central Terai. The scope and achievements of these activities are discussed further, particularly in Chapter 8. In addition, visits have been made to the principal agencies in Kathmandu.

1.4 Report Objectives

The objectives of this report are to:

- present a preliminary evaluation of the factors affecting the groundwater irrigation sector in the Terai and related issues;

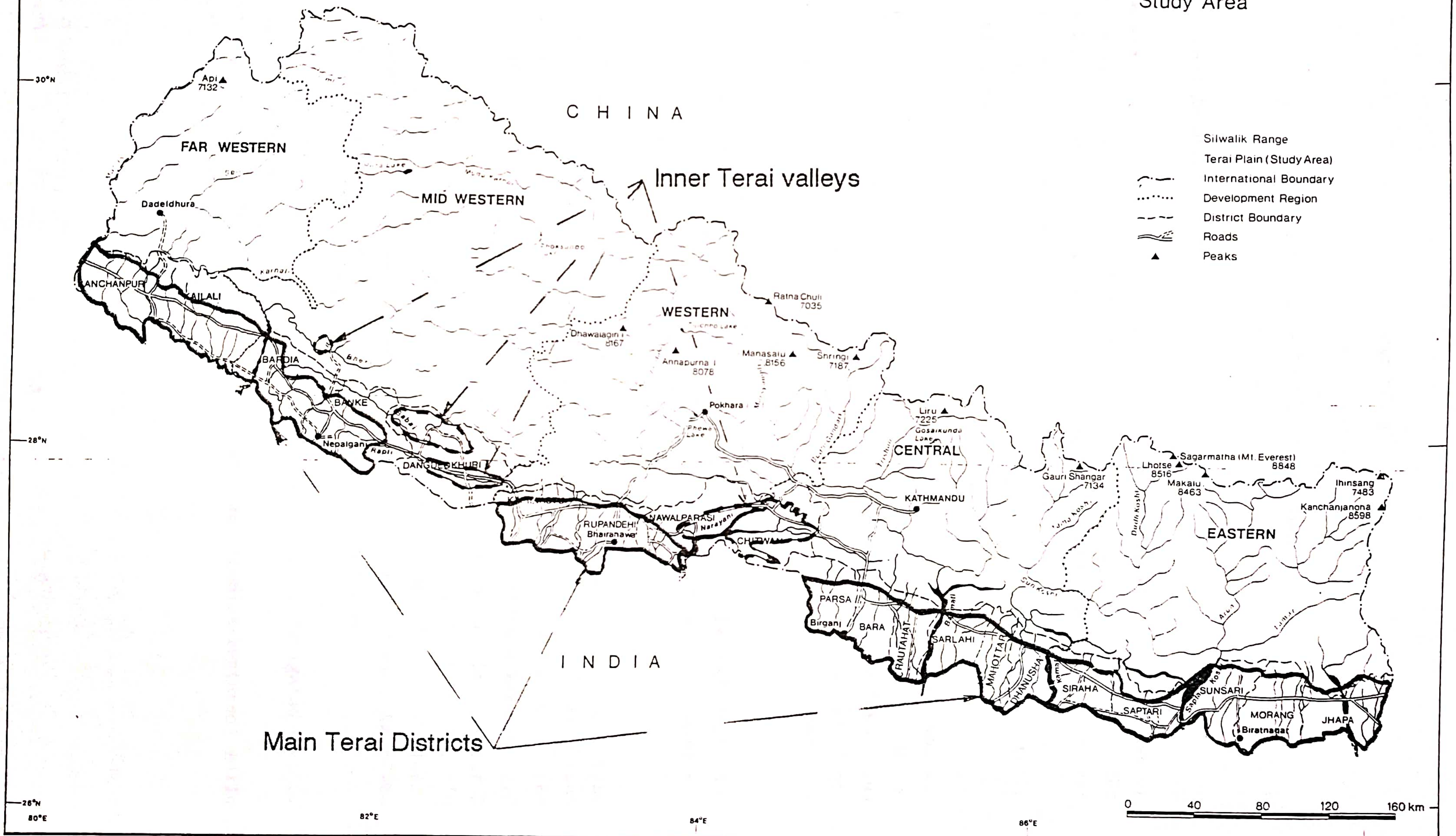
- clarify or amplify any particular issues relating to the Terms of Reference, data availability and the technical approach to be adopted;

- review the main study programme, staffing inputs and associated logistical needs;

- enable the DOI and World Bank to review our findings, and to comment accordingly.

Figure 1.1

Study Area



CHAPTER 2

LAND RESOURCES AND AGRICULTURE

2.1 Land Resources of the Main Terai

Land resources are considered with regard to their suitability for groundwater irrigation and the distribution of suitable land within the Terai zone. The work has been based on the Land Resources Mapping Project (LRMP) reports prepared by Kenting Earth Sciences Limited for the whole of Nepal and completed in 1986, and on observations made during field surveys. The reports are clear and well presented and technically sound.

The Terai forms part of the northern edge of the Indo-Gangetic plain and has mainly alluvial soils. Three land systems or physiographic zones can be recognised. The main features of the various systems and sub-systems (land Units) with their relative positions within the physiography of the Terai are shown schematically in Figure 2.1 which is taken directly from the LRMP Land Systems Report.

Land System 1; the Active Alluvial Plain of the present river channels and river zone, has little agricultural potential due to coarse soil textures and seasonal flooding.

Land System 2; the Recent Alluvial Plain or Lower Piedmont is the most extensive of the three systems and contains most of the irrigable land. Land Unit 2d (55 000 ha) is similar to Unit 3a (discussed in the following paragraphs) in terms of irrigation potential and has therefore been grouped with Unit 3a for this assessment. The other three units within Land System 2 are all suitable for irrigated agriculture and contain most of the Terai's present cultivated land. Unit 2a (185 000 ha) is low-lying and poorly drained, which means that it is good for paddy rice but winter cropping is often difficult because the land does not dry out sufficiently.

Units 2b (515 200 ha) and 2a (396 300 ha) are well suited to irrigated farming of paddy, wheat and other crops.
They are relatively level and have generally loamy (medium-textured) soils capable of giving high crop yields.

Land System 3; the Upper Piedmont or Alluvial Fan Apron complex which covers 626 000 ha (some 30% of the Terai Zone) runs along the northern edge of the Terai adjacent to the Siwalik hills. Of the three sub-systems within Land System 3, Land Unit 3a (271 900 ha) has the greatest irrigation potential, with slopes of less than one degree and generally with light to medium loamy textured soils. It is considered to be in irrigability Class 1 for diversified crops but to have limited potential for the main summer crop, paddy rice, due to its high infiltration rates. This is reflected in the Kenting land utilisation classification, in which Unit 3a is classed as one of the Dry Lands, along with the rest of System 3. Watertables are deeper than in Land System 2, being as much as 10m, deep in places. However, this unit has potential for deep tubewells.

In terms of future groundwater development the 800 000 ha of land in Units 2b and 2c have the highest potential with regard to shallow tubewells. Their topography, and high watertable are well suited to irrigation and both the major irrigated crops, paddy rice and wheat, can be grown. Unit 2a has moderate potential because, though well suited to paddy, much of its area cannot grow winter crops such as wheat due to impeded drainage. There may be potential for winter rice.

Units 2a and 3a are also considered to have only moderate potential due to limited suitability for paddy through excessive drainage and its generally low watertables; (this means that shallow tubewells cannot be used in many areas, and pumping costs are higher). However, these units would be suited to deep tubewell development.

These data are summarised in Table 2.1 to indicate the range of land potential for groundwater irrigation for each main Terai district.

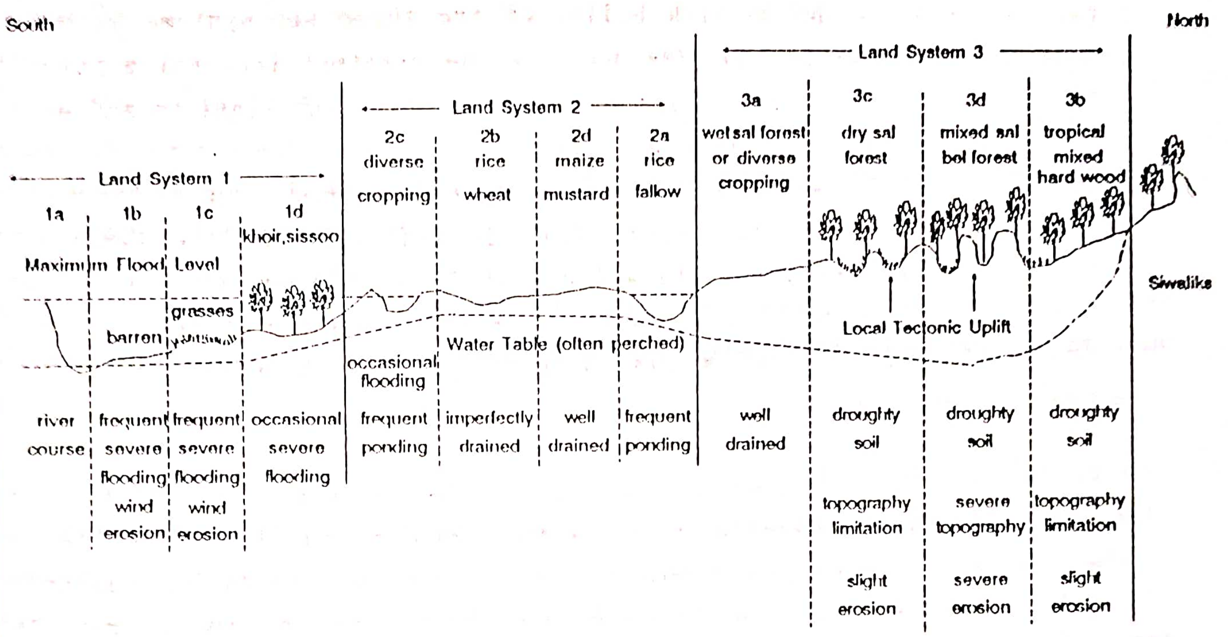
Given the limited detail of the LRMP survey and the inevitable assumptions that had to be made, these figures should be regarded as approximate in nature. Never-the-less, some clear conclusions can be drawn:-

(a) The Terai has a very large area (over 900 000 ha) of high potential land for irrigation, with another 180 000 ha of moderate potential land suitable mainly for rice, and 320 000 ha suitable mainly for dry-land crops by the development of deep tubewells.

(b) Most of the Class 1 land is in the Eastern and Central Regions. These contain about two thirds (500 000 ha) of the high potential land, over half the moderate potential paddy land (100 000 ha) and 60% of the moderate potential dry land (almost 200 000 ha).

Figure 2.1

Schematic Cross Section of Land Systems in the Terai Region



TERAI REGION Quaternary alluvium, Subtropical

Land System	Land Form	Land Unit	Dominant Soils	Dominant Slopes	Dominant Texture	Seasonal Range of Depth to Water Table	Drainage
1	Active Alluvial Plain (depositional)	1a present river channel	-	-	-	-	-
		1b sand and gravel bars	Ustorthents Psamments	< 1°	Sandy/ Cobbly	0 - 2 m	subject to severe river flooding
		1c low terrace	Ustifluvents Fluvaquents	< 1°	Sandy	0 - 2 m	variable; subject to severe river flooding
		1d higher terrace	Ustochrepts Haplaquepts	< 1°	Loamy	0 - 4 m	variable; subject to occasional river flooding
2	Recent Alluvial Plain "Lower Piedmont" (depositional and erosional)	2a depressional	Haplaquepts	< 1/2°	Fine Loamy	0 - 2 m	poor
		2b intermediate position; level	Haplaquepts (Aeric)	< 1/2°	Loamy	0 - 6 m	imperfect
		2c intermediate position, undulating	Haplaquepts Ustochrepts	< 1°	variable	dependent on position	variable; low areas subject to flooding
		2d high position	Haplustolls Ustochrepts	< 1°	Loamy	1 - 10 m	moderately well
3	Alluvial Fan Apron Complex "Upper Piedmont" (erosional)	3a very gentle slopes	Haplustolls Dystochrepts Ustochrepts	< 1°	Loamy	1 - 10 m	moderately well
		3b gentle slopes	Haplustolls	1 - 5°	Loamy/ Bouldery	2 - 10 m	rapid
		3c undulating	Haplustolls	1 - 3°	Loamy	2 - 10 m	well
		3d highly dissected	Ustochrepts	0 - 20°	Loamy	> 2 m	rapid

Source: LRMP Land Systems Report (Kenting Earth Sciences Ltd., 1986).

(c) The distribution of high potential land between the 18 Terai districts, ranges between 22 000 ha or more than 82 000 ha per district.

2.2 Inner Terai Valleys

The inner Terai or Dun Valleys form a conspicuous part of the Siwalik landscapes. The major Dun Valleys in Nepal are: Surkhet, Dang-Deukhuri, Chitwan, Trijua and Kamala valleys, the last two of which are excluded from the Study Area. LRMP has identified three land systems in the Dun Valleys which correspond to the land systems of the main Terai discussed in Section 2.1.

Land System 4; the Active and Recent alluvial plains (145 500 ha) contain sand and gravel bars (65 100 ha)(Unit 4a)and low terraces (18 300 ha) (4b) with coarse loamy soils and severe flooding hazards, hence they are not of agricultural importance. The undulating higher terraces (78 400 ha) (4c) with the soil texture varying from sandy loam to silty clay loam are the most productive lands in the Siwalik landscapes because of reasonably good soils and irrigation water availability. Where gravity irrigation is not available groundwater sources have great potential here, particularly from deep tubewells where they are technically feasible.

Land System 5; fans, aprons and ancient river terraces (308 700 ha), contain very gentle slopes (89 100 ha) (Unit 5a) with sandy loam to silty clay loam soils, well suited to diversified irrigated cultivation; gentle slopes (53 400 ha) (5b) and undulating lands (98 600 ha) (5c) which are suited for upland crops only like maize and millet in the wet season and barley in the winter season. The rest of the area in this land system unit is not suitable for arable cultivation.

Land System 6; depositional basins (57 200 ha) contain depressional lands (14 000 ha) (Unit 6a) and non dissected high positioned lands (16 000 ha) with fine loamy soils that have high potential for intensive irrigated agriculture. Gently rolling lands (18 900 ha) (6c), however, are suitable only under well managed terraced cultivation. The rest of the land in this land system unit are not suitable for cultivation. Figure 2.2 shows a schematical presentation of the inner Terai Siwalik land systems and Table 2.2 summarises the potential land areas for irrigation.

TABLE 2.1

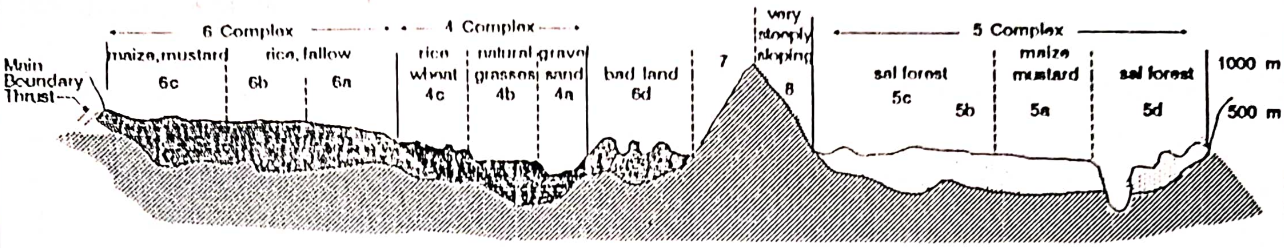
EXTENT OF LAND POTENTIALLY SUITABLE FOR IRRIGATION - MAIN TERAI ('000 ha)

DEVT. REGION District Land Units	Total Terai zone area	High potential 2b,2c	Moderate potential (paddy) 2a	Moderate potential (dry land crops) 3d,2d	Total ('000 ha)
FAR WESTERN					
Kanchanpur	143.2	44.6	3.8	17.1	65.5
Kailali	194.2	76.7	1.7	32.7	111.1
Sub Total	337.4	121.3	5.5	49.8	176.6
MID WESTERN					
Bardia	141.0	49.9	3.8	21.3	75.0
Banke	116.7	22.1	11.7	29.5	63.3
Sub Total	257.7	72.0	15.5	50.8	138.3
WESTERN					
Kapilvastu	147.2	51.1	28.0	12.9	92.0
Rupandehi	120.1	60.7	25.4	5.6	91.7
Nawalparasi	55.5	25.4	8.0	38.5	38.5
Sub Total	322.8	137.2	61.4	23.6	222.2
CENTRAL					
Parsa	105.7	58.1	0.0	4.4	64.5
Bara	112.9	56.3	5.9	34.7	96.9
Rautahat	95.9	45.4	7.2	21.6	74.2
Sarlahi	106.9	54.4	5.9	30.5	90.8
Mohottari	82.0	34.3	6.0	31.0	71.3
Dhanusha	91.3	53.4	11.3	14.8	79.5
Sub Total	594.7	301.9	36.3	137.0	175.2
EASTERN					
Siraha	94.9	53.1	8.9	9.0	71.0
Saptari	104.3	37.4	35.0	1.3	73.7
Sunsari	115.8	59.2	4.3	6.0	69.5
Morang	152.2	81.7	7.0	14.5	103.2
Jhapa	146.7	61.6	7.1	23.3	92.0
Sub Total	613.9	293.0	62.3	54.1	409.4
Total Terai	2 126.5	925.4	181.0	315.3	1 421.7

Source: Appendix 5 of the Land Systems Report, Land Resource Mapping Project, Kenting Earth Sciences Limited, 1986.

Figure 2.2

Schematic Cross Section of Land Systems in the Siwalik/Churia Hills Region



(Depth to bedrock not known)

Interbedded Semi-consolidated Tertiary Sediments — Lacustrine Sediments

Alluvial Sediments — Alluvial Fan and Terrace Sediments

SIWALIK HILL REGION   Tertiary interbedded sandstone, shale, conglomerate and Quaternary alluvium; Subtropical

Land System	Land Form	Land Unit	Dominant Soils	Dominant Slopes	Dominant Texture	Seasonal Range of Depth to Water Table	Drainage
4	Active and recent Alluvial Plains	4a sand and gravel bars	Ustorthents Psamments	< 1°	Sandy/ Cobbly	0 - 2 m	subject to severe river flooding
		4b low terrace	Ustifluvents Fluvaquents	< 1°	Sandy	0 - 2 m	variable; subject to severe river flooding
		4c higher terrace undulating	Ustochrepts Haplaquepts	< 1°	variable	dependent on position	variable; low areas subject to flooding
5	Fans, Aprons and ancient River Terraces (Tars)	5a very gentle slopes	Haplustolls Dystrochrepts Rhodustalfs	< 1°	Loamy	1 - 15 m	moderately well
		5b gentle slopes	"	1 - 5°	Loamy/ Bouldery	2 - 15 m	rapid
		5c undulating	"	1 - 5°	Loamy	2 - 15 m	well
		5d rolling	"	0 - 20°	Loamy	2 - 15 m	rapid
6	Depositional Basin (Duns)	6a depressional	Haplaquepts	< 1/2°	Fine Loamy	0 - 2 m (perched)	poor
		6b non dissected high position	Ustochrepts Haplaquepts	< 2°	Fine Loamy	0 - 6 m (perched)	imperfect
		6c gently rolling	"	1 - 5°	Fine Loamy	2 - 15 m	variable
		6d highly dissected	Ustochrepts	0 - 30°	Fine Loamy	> 15 m	rapid
7	Moderately to Steeply Sloping Hilly and Mountainous Terrain		Lithic, Typic and Anthropic Subgroups of Dystrochrepts Ustochrepts	< 20°	Loamy Skeletal	no water table < 1 m to bedrock	well
8	Steeply to very Steeply Sloping Hilly and Mountainous Terrain		Lithic Subgroups of 7 and Ustorthents	> 20°	Loamy Skeletal	no water table < 50 cm to bedrock	rapid

Source: LRMP Land Systems Report (Kenting Earth Sciences Ltd., 1986).

Future land resource studies will concentrate on mapping the distribution of soils of the inner Terai valleys and the main Terai in outline form, using the LRMP 1:125 000 scale land system maps. These maps will then be used in conjunction with the groundwater potential maps to identify those areas with the greatest development potential.

Apart from the land's physical potential, another factor that will influence the development priority which different areas may be given in the short and medium-term future, is the present land use. The scope for rapid development of groundwater irrigation will be greater in areas that area already under cultivation than in areas where the forest has not yet been cleared. Current land use on the Terai's irrigable land will be considered early in the main study period in 1993, but some indication of the degree to which land is already being cultivated can be obtained from the LRMP figures of population densities. It is reasonable to assume that cultivation intensities are greater where population densities are higher.

The LRMP data shows that densities exceed 200 persons per square kilometre in all the Terai districts of the Central and Eastern Regions, but are lower in the Far Western, Mid Western and Western regions.

The implication is that a lower proportion of cultivable land has been developed in these regions than in the Eastern and Central Regions, which is supported by the fact that the population per hectare of cultivated land is also lower, generally 3-4/ha, compared with 4-6/ha in the Eastern and Central Regions. However, every district and region has potential for the development of ground water resources, and in regard to poverty alleviation and to the promotion of development in the less developed regions, all areas must be given equal consideration.

2.3 Soils

The Terai region consists of recent and post pleistocene alluvial deposits which form piedmont planes adjacent to the Himalayan mountains. Two piedmont planes are distinct; lower and upper piedmonts.

The lower piedmonts have usually coarse textured Ustorthents, Ustifluvents, and Ustochrepts in the areas adjacent to the rivers and are subject to severe to occasional flooding; poorly drained fine loamy typic Haplaquepts with low infiltration rates occur in the depressional lands and imperfectly drained coarse loamy Aeric Haplaquept in the intermediate areas. These Aeric Haplaquepts are somewhat more permeable than the more typical Haplaquepts.

TABLE 2.2

EXTENT OF LAND POTENTIALLY SUITABLE FOR IRRIGATION: INNER TERAI VALLEYS ('000 ha)

DEVT. REGION District Land Units	Total (Inner Terai)	High potential 4c,5a 6a & 6b	Moderate potential (paddy) 6c	Moderate potential (dry land crops) 5b & 5c	Total ('000 ha)
Chitwan	115.8	62.0	7.7	28.4	98.1
Dang Deokhuri	114.5	49.7	10.3	21.6	81.6
Surkhet	31.0	9.1	0.7	15.1	24.9
	251.3*	120.8	18.7	65.1	204.6*

Note: * these data are for all the valley lands within Surkhet District; the area of the district included in the currentStudy Area (that in the small valley surrounding Birendranagar) is some 5 200 ha (gross) of which some 4 900 ha are included in Units 4c, 5a, 5b, 5c and 6a, 6b and 6c.

Source : Appendix 5 Land System Report, LRMP, 1986

The higher areas of the lower piedmont have mostly moderate to well drained Ustochrepts and Haplustolls and these have relatively higher infiltration rates.

The upper piedmonts have rapid to well drained coarse loamy Haplustolls, Ustochrepts and Dystrochrepts depending upon their land positions and they generally have high infiltration rates.

The inner Terai valleys are part of the Siwalik landscapes. They have mostly sandy Ustifluvents, Ustochrepts, and some Haplaquepts (in the depressions) in the areas adjacent to the rivers. They have generally high infiltration rates.

Those areas away from the influence of rivers have moderately well to well drained Haplustolls, Dystrochrepts and Rhodustalfs depending upon land position.

The pH of the soils vary with the parent materials they are formed from and the type of the cultivation. Active alluvial plains have generally Calcarious soils. The alluvial soils of the Terai are mostly strongly to moderately acidic in nature and they are used mainly for the rice cultivation. Under anaerobic conditions (flooded rice) soil pH rises to neutrality negating the detrimental effects of low pH.

Organic matter content of cultivated soils range from 0.5 to 3 % (Av. 1.5 %).

Nitrogen is the most limiting nutrient in the cultivated soils and virtually all cultivated fields experience nitrogen deficiency.

Phosphorous content is low to medium and deficiency is obvious only at higher Nitrogen applications and under intensive cropping. At the present level of chemical nitrogen utilization and high application of farm yard manures, phosphorus does not seem to be limiting at present except for the legumes which fail to form effective nodules without its application.

Nepalese soils are relatively rich in potassium; on an average 0.2 meq/100 gm soil, sufficient to supply adequate potassium at present crop yield.

2.4 Cropping Systems

There are numerous cropping systems described for the Terai in the various reports and surveys.

But for the great majority of farmers there are only few basic systems often practised simultaneously in different fields, and modified by the land physical conditions; (that is the relative areas of khet (rice land), bari (elevated but usually leveled and bunded land, rough un-leveled land and low wet land).

In the khet and bari fields rice is planted in the wet season followed by wheat or pulses/oilseeds in the cool season. A great majority of the Terai is planted in this way and although the wet season crop is always rice the proportions of wheat and pulses vary according to the farmers' needs, prevailing prices and so on. However, these variations cannot be considered to be more than one cropping system.

The cropping system that represents the majority of farms in the general Terai is as follows:

Rice (Monsoon Season)-- Wheat/Pulse/Oil Seed (Winter) (1)

Irrigation has the effect of increasing the area of wheat over pulses and oil seeds in many instances since wheat responds better to irrigation. The pulses and oil seeds commonly grown in the winter season are chick pea, lentil, linseed and mustard. When irrigation is available the proportion of mustard tends to increase since this crop is often given one or two irrigations.

Chickpeas and linseed are usually not irrigated. Pigeon peas are usually grown on rough land over a twelve month period and are not irrigated as this crop utilises water deep in the soil profile and flourishes well without irrigation.

The other widespread cropping patterns seen is rice-fallow or rice-oil seed/pulse in which the latter are simply broadcast without cultivation into the rice crop around harvest time:

Rice (Monsoon Season)-- Fallow/OilSeed/Pulse (Winter) (2)

Such relay-sown cash crops (usually chick pea and linseed) give only marginal yields under such conditions). This cropping pattern occurs on the low lying wetlands (usually classified as R2 land), in which drainage is impeded so that a good winter crop of wheat cannot be obtained without recourse to ridging or broad bed construction.

The relatively large farm areas in the Terai distract from the more intensive use of land involving ridging for wheat cultivation. Other areas used for the rice/fallow cropping system are elevated bari lands that have been made into leveled paddies in which there is no prospect of irrigation at present. Around 75 % of the Terai farm area is used for systems (1) and (2) above and these system are characteristics of larger farms above 1-2 ha in extent.

Maize is not an important crop in the general Terai and is usually planted on higher and less well leveled land. However, in the inner Terai maize/ mustard is a common cropping system:

Maize (Monsoon Season)-- Mustard (Winter) (3)

Less than 10 % of the Terai comprises farms of 1 ha or less in size and only around 2.8 % of the land area comprises farms of less than 0.5 ha in extent. In terms of farm numbers, however, some 58 % of farms are less than 1 ha in extent and around 45 % of farms are less than 0.5 ha in extent. These farms occur in the more densely populated areas of the Terai, and many of these areas are irrigated. Intensive cropping is practised and high yields are obtained.

In some instances double rice planting is practised followed by wheat/ oilseed/ pulses:

Rice (Spring)-- Rice (Monsoon)-- Wheat/Oilseed/Pulses (4)

In irrigation areas around Birganj around 25 % of farmers plant two rice crops on farms of less than 0.5 ha and high yields are obtained. Here the winter crops comprise around 60 % wheat and 40 % oil seed and pulses. Here also, small areas of sugarcane and tobacco are also grown.

2.5 Impact of Irrigation

Detailed agricultural studies will be carried out over the period of wheat harvesting and paddy planting in 1993. However, it is apparent that the introduction of irrigation usually results in an increase in the area of wheat relative to pulse and oil seeds in systems (1) and (2) and a significant increase in both wheat, rice and, in some cases, oil seeds and pulse yields. In relatively small areas, spring rice planting (4) above, also increases. Tables 2.3 and 2.4 show summaries of irrigation effect on rice and wheat yields, from different sources.

In the two cases of the maize--mustard system (3) above, irrigation in many instances changes cropping patterns to maize- paddy- mustard:

Maize (Spring)-- Paddy (Monsoon)-- mustard (Winter) (5)

Apart from the obvious direct effect of increasing crop yields and cropping intensity (reduction of fallow lands and planting of additional crops), irrigation has a secondary and very important effect of increasing crop security. It is this factor that disposes farmers to use more inputs and makes it possible to promote, through the research and extension services, more productive farming systems.

TABLE 2.3

SUMMARY OF ESTIMATES OF IRRIGATION ON PADDY YIELDS IN FARMERS' FIELDS IN THE TERAI (t/ha)

Source of information		Irrigated	Rainfed	Increase
WEC (1985) (1)		3.50	1.70	1.80
APROSC (1983)	HYVs (1) (2)	-	-	0.60
	Locals	-	-	0.35
FIWUD (Bara and Parsa)(1) (2)		-	-	0.07
No Frills O and M Study (1984) (1)		-	-	0.8-1.8
Sagarmatha IRDP		-	-	0.90
ADBN 5th Agric Credit Report (1986)		-	-	1.00
DFAMS Cost of Production Report (1990/91) (2)				
1985/6 Data	(HYV's)	2.43	2.08	0.35
	(locals)	2.10	1.90	0.20
1986/7 Data	(HYV's)	2.57	2.02	0.55
	(Locals)	2.07	1.79	0.28
Block Production Prog. (1985/6)(4)		3.2-4.5	2.06(3)	1.1-2.4
WECS (1987) (5)	Chandra Canal	2.30	1.23	1.07
USAID (1986)	Budhabare (1) (2)	2.8-3.6	2.06 (3)	1.14
	Lothar	3.0-4.0	2.06 (3)	1.44
	Auraha	2.4-4.5	2.06	1.39
	Kamala	1.5-3.5	2.06	0.44
	Kankai (Head)	3.1(head)	2.2(tail)	0.90

Sources:

(1) Farmers' Estimates
(2) Crop Cuts
(3) Agriculture Statistics of Nepal 1990
(4) DOI Successful Completion of Block Production Program in Nepal (1986)
(5) Water and Energy Comm. Rapid Appraisal Report (1987)
(6) USAID Rapid Appraisal of Nepal Irrigation Systems (1986)
    Water Management Studies Report No. 43

TABLE 2.4

SUMMARY OF ESTIMATES OF IRRIGATION ON WHEAT YIELDS IN FARMERS' FIELDS IN THE TERAI (t/ha)

Source of information		Irrigated	Rainfed	Increase
WEC (1985) (1)		2.40	1.20	1.30
APROSC (1983) (1) (2)		-	-	0.3-0.7
FIWUD (Bara and Parsa)		-	-	1.20
No Frills O and M Study (1984) (2)		-	-	0.7-1.5
Sagamartha IRDP (1) (2)		-	-	0.8-1.0
ADBN 5th Agric Credit Proj. (1986)		-	-	1.00
Block Production Program (1985) (2) (4)		1.8-3.6	1.40(3)	0.4-2.2
DFAMS Cost of Production Report (1990/91) (1) (2)		1.65	1.42	0.23
WECS (1987) (5)	Chandra Canal	1.93	1.40 (3)	0.43
USAID (1986) (6)	Budabhare	1.8-2.0	1.40 (3)	0.50
	Lothar	2.0-3.5	1.40 (3)	1.35
	Auraha	2.0-3.5	1.40 (3)	1.35
	Kamala	1.5-2.5	1.40 (3)	0.60
	Kanaki	1.9(head)	1.4(tail)	0.50
UNDP (1991) (7)	Kapalvastu	0.7(head)	0.6(tail)	0.10

Sources:

(1) Farmers' Estimates
(2) Crop Cuts
(3) Agricultural Statistics of Nepal (1990)
(4) DOI, Successful Implementation of Block Production Program in Nepal (1986)
(5) Water and Energy Comm. Rapid Appraisal Report (1987)
(6) USAID Rapid Appraisal of Nepal Irrigation Systems (1986) Water Management Studies Report No. 43
(7) UNDP Irrigation Sector Support Project. Socio-Economic Baseline Studies of the ILC Pilot Sub Projects Annex-F

2.6 Agricultural Support Services

To obtain the maximum benefit from irrigation it is necessary to provide technical services in the form of appropriate cropping packages, to see that inputs of seed, chemicals etc. are available, and in some instances to provide credit for inputs. (Even in very small farms in the intensively farmed areas of the Terai it is found that crop areas are sometimes limited by cash for seeds and fertilizers).

The agricultural extension services are at present very few, and there is a need to greatly increase and support agricultural extension in irrigation areas.

Similarly there is a need to support appropriate research and outreach programs, particularly for the development of crop varieties and systems suited to the more extensive farms of the Terai which account for more than 75 % of the land area and also for the areas least servised by irrigation schemes.

In considering the effects of irrigation it can be seen that there are two phases for crop yield change; an immediate effect due to irrigation, which may be quite small (particularly in rice) and a longer term effect that comes about with improvement in farming practices and water management resulting from appropriate research and extension activities.

For the latter phase, attention will need to be given to the development and extension of appropriate technological packages for larger farms in the 1.5 ha and above category.

2.7 Water Management

Water management research and extension now comes under the Irrigation Management and Water Utilisation Division (IMWUD) of the DOI. This Unit has two sections; Research and Training, and Services. It's approach is to promote farmers' participatory activities through registered water-user associations. At the present time, activities are concentrated on larger irrigation schemes. There will be a need to consider an approach for improvement of water management for STWs and small-group irrigated farming.

CHAPTER 3

GROUNDWATER IRRIGATION IN THE TERAI

3.1 Agencies

The Groundwater Resources Development Board (GWRDB) under the Department of Irrigation (DOI) of the Ministry of Water Resources and Power, is the primary government agency responsible for groundwater investigations and development in Nepal. GWRDB's activities in the Terai were consolidated in 1979 with the start of the USAID sponsored hydrogeological investigation in the western half of the Terai and carried out with the United States Geological Survey (USGS).

GWRDB's activities, now implemented through the Groundwater Resources Development Project (GWRDP) and certain area-specific projects, include installation of investigation and production wells, basic data generation, monitoring of overall groundwater development and associated utilisation, and operation and maintenance of production wells. In 1987, these were expanded to include the UNDP/GWRDB shallow aquifer studies and, more recently, the groundwater components of the IDA funded irrigation line of credit (ILC) programme. These are discussed further in Sections 3.3, 3.4 and Chapter 4.

Examples of current area-specific investigations include the IDA funded Stage III development for the Bhairahwa-Lumbini Groundwater Irrigation Project (BLGWP), the JICA funded investigations in Jhapa District and the IDA funded feasibility study being undertaken for GWRDP by Nippon Koei.

Historically, GWRDB has been more concerned with deep tubewells (DTWs); typically these are rotary drilled to 150 m, screened with or without a gravel pack, and pumped at between 45 and 120 l/s with submersible pumps which may be diesel or electric powered.

GWRDB is also involved with shallow tubewells (STWs), both under the ILC groundwater programme and its locally financed programme and, formally, as executing agency for the Sagarmatha Integrated Rural Development Programme (SIRDP) and, more recently, the UNDP/GWRDP shallow aquifer studies.

STWs are drilled by a variety of both complex and simple methods to typical depths of 40 m, and pumped at about 13 l/s with surface-set centrifugal pumps.

GWRDP is also investigating the use of intermediate capacity 'Medium' tubewells as part of the ILC programme.

There are four other agencies which are (or have been) notably involved in Terai groundwater irrigation; the Agricultural Development Bank of Nepal (ADBN), Narayani Zone Irrigation Development Project (NZIDP) under DOI near Birganj, the Janakpur Agricultural Development Project (JADP) in the eastern Central Region and the erstwhile Farmer Irrigation and Water Utilisation Division (FIWUD) of the Ministry of Food and Agriculture, (and transferred in 1991 to DOI as IMWUD).

NZIDP is primarily a surface water development, but has 29 production DTWs grouped between Birganj and Kalaiya to the north of the Nepal Eastern Canal; NZIDP is also understood to have installed some 63 STWs for community use in small areas of the eastern part of the surface irrigation system which are locally out of command, but which have not yet been commissioned.

ADBN is extensively involved in STW development throughout the main and inner Terai districts. It continues to be the main vehicle for disbursing credit for farmers to purchase wells through the AsDB funded Fourth, Fifth and current 6th Agricultural Credit projects. To date some 24 500 STWs have been installed under direct ADBN credits to the general Terai private sector, and an additional 5 000 through ADBN in JADP and SIRDP; altogether an installed capability for irrigating some 120 000 ha at reasonable levels of utilisation.

The total rate of STW installation by ADBN in 1992/92 was 2 723 per year, compared with the peak of 3 829 in 1988/89 which was followed by much reduced rates of about 1 300 STWs per year in the two intermediate years. ADBN's stated target in 1987 was 74 000 STWs by year 2000 to irrigate 40% of the cultivable Terai.

ADBN also provides credit for installing dug wells, and these are of particular local importance in parts of Chitwan and Surkhet where sub-surface conditions are too cobbly to permit the more common indigenous drilling methods.

JADP is a project under the Agriculture Department (DoA) of the Ministry of Food and Agriculture, and involved with groundwater development in the three Terai districts of Janakpur Zone, with some further wells in Chitwan District. The project is now under an operation and maintenance phase under DoA, based north of Janakpur.

Many of the earlier DTWs, particularly those drilled under the USGS/GWRDB investigations, were installed for investigation rather than production purposes. FIWUD co-operated closely with GWRDB in a programme to commission several of these wells, and has been involved in providing pumpsets, irrigation distribution systems and active extension inputs to develop on-farm water management; the programme includes both free flowing artesian and pumped DTWs, and FIWUD managed about 30 such schemes before handing over responsibility to IMWUD in 1991.

During the study we will examine the activities of the various agencies and their associated objectives, funding and methods, and will incorporate these findings into the overall strategy preparation.

3.2 Development History and Current Development Levels

3.2.1 Development History

Groundwater development in the Terai was preceded in the period 1969-1974 by a major programme of groundwater exploration, under the sponsorship of the former Department of Irrigation, Hydrology and Meteorology (DIHM), the Ministry of Food and Agriculture and USAID, and under the technical control of the United States Geological Survey (USGS).

Investigations were carried out in the following zones of Terai:

- -Seti and Mahakali Zones, Far West (Kanchanpur and Kailali Districts);
- -Lumbini Zone, West (Kapilvastu, Rupandehi and Nawalparasi Districts);
- -Bheri Zone, Mid West (Bardia and Banke Districts).

A total of 189 exploratory boreholes, of aggregate 26 460 m and of maximum depth 457 m, were drilled. These bores were geophysically logged, cased at 100 m (4") and 150 mm (6") diameter and screened, generally over 6-9 m sections in the deep aquifer. Over 60% of these bores were then pump tested to establish estimates of aquifer parameters.

Development then proceeded from these basic resource investigations, and in some cases, the USAID investigation bores were converted for irrigation use.

The following developments have occurred:

- the Bhairahwa-Lumbini irrigation project based on deep tubewells (DTWs). This IDA assisted project was initiated in 1978 and Stage III is currently under construction;

- completion of irrigation DTWs by GWRDB alone or within specific projects (i.e. SIRDP,JADP,BIP,BLGWP): over 300 DTWs have been installed. In addition, GWRDP has a continuing programme of exploration borehole drilling throughout the Terai.

- the ILC pilot project which was launched in 1989 and currently receives funding through the Mahakali Stage II and BLGWP Stage III loans. The project aims to expand farmer managed irrigation and farmer participation. GWRDP are currently implementing the groundwater component of the ILC programme. They are installing shallow tubewells (STWs),medium tubewells (MTW) and DTWs, in area clusters.

  Currently work is in Kapilvastu, Nawalparasi and in Dang Valley while later work is planned in Kailali, Kanchanpur and Banke Districts. In Kapilvastu and Nawalparasi, the programme has so far installed the following:

District	DTWs	MTW/STWs
Kapilvastu	7	40
Nawalparasi	6	35

  (MTWs are tubewells up to 100 m deep in which either suction or force mode pumps are used, depending on water level-drawdown considerations.)

- STW development, which is continuing throughout the Terai. The STWs are being installed through direct ADBN credit, and subsidy (although subsidy was withdrawn early in 1993), either through SIRDP of with farmer contribution. To date, ADBN has supported over 24 000 STWs. It appears that very few STWs are being installed with entirely private/farmer funding.

In addition, ADBN has also supported over 3 000 STWs through JADP.

Estimates of STWs and DTWs so far installed in the Terai are given in Table 3.1; the ADBN totals are firm but other estimates are under review.

The Janakpur Irrigation Project (JADP) is carrying out some irrigation with groundwater, and has installed both STWs and DTWs. Similar development, based on DTWs, is occurring within the Narayani Irrigation Project.

3.2.2 Current Development Levels

Provisional estimates of the distribution and numbers of both DTWs and STWs are given (Table 3.1). ADBN data are valid to mid 1992 (end of 1991/92 financial year) while the other figures are being reviewed.

The data allow some indication of the pace and present intensity of groundwater development for irrigation. If discharges of 15 l/s and 75 l/s are assumed for STWs and DTWs respectively, then the data in the Table suggests an installed capacity of almost 31 $l/s/km^2$ for the irrigable land area in Terai of 16 300 km^2. If net cultivable area is assumed as 80% of gross, then this gives a rather low installed capacity of 0.25 l/s/ha net compared with a total in the range 1.5 to 2.0 l/s/ha required for complete groundwater irrigation coverage (a hypothetical comparison since very significant areas of the Terai are served by a series of DOI and farmer built surface irrigation systems).

3.3 Deep Tubewell Irrigation

Initially DTW development was commonly perceived as a rapid and cost effective way of using sophisticated drilling rigs and associated plant to bring rainfed areas under intensive irrigation; in unit-cost-of-water production terms this was normally true. However, experience with the first stage BLGWP and Birganj wells demonstrated only too clearly that there were difficulties in mobilising and managing large numbers of farmers to bring about reasonable levels of well utilisation (and therefore irrigation intensity); in surveying, designing and constructing water distribution systems; and in assessing and collecting payments for the water supplied and for operation and maintenance. There were also difficulties in achieving remotely reasonable irrigation intensities and water management efficiencies.

These limitations have been clearly been recognised, with the result that there is now a clear policy aimed at turning such wells over to the recipient farmers groups, and in mobilising farmer response and interest so that they are truly involved in the concept, location and design of DTW units and associated distribution facilities.

TABLE 3.1

TENTATIVE DISTRIBUTION OF IRRIGATION TUBEWELLS 1991-92: TERAI AND INNER TERAI

Development Region	District	DTWs		STWs			
		DTWs	Agency	ADBN	DOI	JADP	Total
Far West	Kanchanpur	14	USAID/GWRDB	1,764	603		2,367
	Kailali	68	USAID/GWRDB	2,408	497		2,905
	total	82					5,272
Mid West	Bardia	0		1,482	?		1,482
	Banke	5	USAID/GWRDB	1,542	?		1,542
	Surkhet*	0			?		?
	Dangdeukhuri*	4	GWRDB	401	471		872
	total	9					3,896
West	Kapilvastu	41	GWRDB	409	49		458
	Rupandehi	110	BLGWP	2,517	?		2,517
	Nawalparasi**	11	GWRDB	686	17		703
	total	162					3,678
Central	Chitwan*	0		224	17		241
	Parsa	3	BIP	314	25		339
	Bara	28	BIP	2,230	25		2,255
	Rautahat	0		1,285	20		1,305
	Sarlahi	15	JADP/GWRDB	400	20	1301*	1,721
	Mahottari	24	JADP/GWRDB	211	16	625*	852
	Dhanusha	77	JADP	474	23	1073*	1,570
	total	147					8,283
East	Siraha	9	SIRDP	399	925**		1,324
	Saptari	9	SIRDP	183	1004**		1,187
	Sunsari	0		2,963	53		3,016
	Morang	1	GWRDB	2,266	54		2,320
	Jhapa	2	GWRDB	2,258	6		2,264
	Udayapur	0		3	72**		75
	total	21					9,186
Total Terai		421		24,419	4,621	2,999	30,315

Notes: Some 300 exploratory DTWs drilled under USAID/GWRDB, HMGN/GWRDB and DOI/GWRDB programmes are omitted, unless selected for irrigation.

* possible double counting with ADBN: target was 2920 STWs by mid-1988
** under SIRDP

ADBN data correct to mid 1992: other data under review

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This revolves around extensive farmer participation by farmers before the start of any work on wells; and contributions of one form or another whilst installing and later operating the scheme; and is the core of the ILC policy.

We will examine the experience gained to date in the light of our own DTW related studies in the field and in Kathmandu, incorporating experience gathered from other countries in the region, notably from Bangladesh. This work will include comparison between intensive project orientated and more random demand driven siting procedures. We will also examine the recommendations for DTW development currently being prepared by Nippon Koei.

3.4 Shallow Tubewell Irrigation

One of the main conclusions of the 1987 study was that utilisation of STWs was disappointingly low; both in terms of the lost agricultural production potential and related returns to the owner, and in terms of the resulting disincentive to more widespread STW use. At the time, average area irrigated by STWs in the Terai was estimated at about 2.25 ha, (and 4 ha was considered a reasonable target).

We will use our available resources as extensively as we can to assess the current levels of STW use within the Study Area, and to identify related constraints and mitigation measures; agronomic, technical, social and institutional. We will extend this work to dug wells in areas where they are important.

It is very likely that the availability of STWs to groups will be a particularly important aspect of the overall groundwater irrigation development strategy. We will take particular interest in the approaches to setting up community wells initiated through ADBN's small farmer development programme (SFDP) and the ILC groundwater component; also in other current approaches, for example the proposals under preparation by IFAD for developing community STWs in the Eastern Region.

3.5 Social Issues in the Tubewell Irrigation Sector

A number of social issues still remained to be explored at the end of the 1987 study due to resource constraints. This Section discusses some of the most prominent ones.

(a) Ethnicity and social power

Nepal is a highly stratified Hindu society where caste overrides even Buddhist practice. While in urban society social power is not based solely on caste, caste and land ownership go more closely hand in hand in rural Terai and inner Terai village society. There is a distinct tendency for higher caste larger landowners to dominate water interests in DTW schemes and group STWs. We already know from the 1987 Study that they are more likely than their lower caste and resource-poor neighbours to be able to buy individual STWs: perhaps because they are not so pinched by monetary pressures they are less likely to be selling water? This is all of course contrary to the Basics Needs Program of the previous government and the social equity emphasis of the new government which has recently eliminated all subsidy for shallow tubewell purchase.

(b) Constraints on resource-poor peasant farmers

To benefit more from tubewell irrigation than just having water insurance, irrigators have to be able to invest in HYV seed and chemical inputs as well as diesel fuel and lubricants for STWs, or water charges tied to electricity rates in DTWs. When prices of dry season wheat are barely perceived to reward such investment, farmers who mainly prefer rice and maize as staple food grains, may see little reason to expand areas under wheat: (how many chapattis can a Terai family eat together with its rice and how much suji porridge can parents feed to their children?).

Such farmers, being denied the attention of agricultural extension agents, cannot easily determine what to grow, on their now potentially irrigated farms, that will bring profit to them from the market. These are the resource-poor peasant farmers who are lucky enough to find themselves in an area organized by the SFDP (of the ADBN), or in a more rare, very well functioning DTW group. Moreover, agricultural credit will not help farmers whose market terms of trade do not yield much profit.

Even farmers with slightly higher landholdings, complain that while meeting their loan payments on time, and buying diesel and lubricating oil, they are unable to celebrate Desain (the biggest of the Nepali Hindu holidays) with anything at all special for their families.

(c) Rainfed agriculturalists and tubewell irrigation efficiency

While in some areas farmers irrigating with water from tubewells have experience with surface irrigation water, in many other areas they have not had such experience. The practices of moving water from field to field which sufficed for rice under rainfed conditions will prove inefficient and costly for tubewell irrigated wheat in the dry season.

(d) Long-term cultivation of the same land

Farmers who have worked the same land over a long period of time come to understand the peculiarities of each and every one of their scattered parcels. In some cases such information is passed from father to son over several generations in which knowledge accumulates; this must account at least in part for their success in developing farmer irrigation systems and associated water management aspects.

Such depth of understanding of the capability of land parcels cannot be expected of more recent migrants to the Terai and inner Terai valleys from the hills, where they were also likely to have been farming under rainfed conditions. Consequently, in the absence of widespread and efficient soil testing and close attention from well trained extension agronomists and/ or successful and effective demonstration foci, understanding the land and its capabilities can not be expected to take place quickly.

CHAPTER 4

GROUNDWATER RESOURCES AND DEVELOPMENT

4.1 Data Base

The more important sources of hydrogeological data are given in Table 4.1.

Since 1987, the GWRDB, supported by UNDP, has conducted a major investigation of the shallow aquifer in all 21 districts of the main and inner Terai; publication of hydrogeological reports for all districts is almost complete. These investigations included borehole drilling, testing and water level monitoring in the shallow aquifer zone; lithological logs, and pump test analysis. Maps of water level depth, and water level change over 1-2 years, are given, together with some recharge calculations and notes on the suggested approach to the mathematical modelling of the districts.

The particular importance of this work is that it presents water level depth and change data for much of the Terai; such data are essential to allow the 1987 mapping of the limits of suction and force mode pumps in Terai to be updated and improved. The delineation of areas where suction pumps can reliably be used, is fundamental to development planning.

Other important data, on shallow tubewells (and some deep tubewells) in the Kapilvastu and Nawalparasi districts, is available from the on-going work of GWRDP-ILC groundwater project, based in Bhutwal.

Basic data on the deep aquifer lithology, aquifer characteristics and piezometry, are available from the USAID/USGS exploratory boreholes drilled in Bheri, Lumbini, Seti and Mahakali Zones, in 1969-74. These exploratory boreholes were cased at 6 and/or 4 inches (150 - 100 mm), contain very short screens, and were often tested at low discharges; consequently, results on borehole specific capacity, and aquifer characteristics, may not be directly appropriate to large diameter irrigation tubewells.

Recent data on construction, development and testing of high capacity DTWs are available from Birganj (BIP), from the Bhairahwa-Lumbini project (BLGWP) and from JADP; also from the current exploratory drilling under way at Jhapa.

Additional data on STWs and DTWs is being acquired from GWRDB, which agency has a limited programme of exploratory borehole drilling, controlled through GWRDP district offices.

The historic behaviour of the deep aquifer is of interest, particularly in the Bhairahwa-Lumbini area where the aquifer has been exploited for over 20 years.

Somewhat inadequate, fragmentary piezometric records were available to the 1987 study. For non-artesian DTWs, some analysis was possible by examination of overlapping record to indicate that stabilisation in water levels has generally occurred, once head falls (averaging about 3 m) which followed the onset of production pumping had taken place. The piezometric record for flowing artesian DTWs was poor and not adequate to determine the trend of head change in the artesian zone; small head falls, and zero head declines, were shown by different wells. It was concluded that the poor record was because of the difficulties in measuring shut-in-head, due to leaks and inadequate time for head recovery after discharge.

We propose to reexamine the BLGWP records,including any monitoring that has taken place since 1987, since evidence for possible head decline, or seasonal head variations, is of considerable interest in development strategy. However, it does appear that no purpose-built artesian piezometers exist, and that there has been no systematic monitoring of the artesian pressures, either at pump-assisted production wells or in piezometers.

However, spot measurements taken at borehole completion in the period 1969-74, are available for some USGS/USAID boreholes; some of these have been converted for irrigation and it may be possible to make shut-in-head measurements at these boreholes, to detect any head decline. Boreholes in the Bhairahwa-Lumbini area are of especial interest, because there is substantial pumped and free flow abstraction (Tahal estimate abstraction of 67 million cubic metres per annum for the period 1984-90) from the artesian aquifer, yet no piezometers exist in the deep, artesian zone.

Data on DTW construction, development and testing, and operational characteristics are being obtained from several other on-going projects; of particular interest are changes in artesian head and related discharge changes, and how and over what time period these occur. Changes in specific capacity with time (an index of screen clogging or blockage) will be of particular interest.

TABLE 4.1

HYDROGEOLOGICAL DATA SOURCES

Category	Type	Data Sources
Shallow aquifer	Piezometry, lithology and geometry, water level variation, aquifer characteristics.	UNDP/GWRDP shallow aquifer investigations, 1987-92, in all districts of main and inner Terai.
		Some USGS/USAID exploratory drilling in 1969-74
		GWRDP-ILC groundwater project (currently in Kapilvastu & and Nawalparasi Districts)
	Shallow aquifer monitoring	GWRDP
Deep Aquifer	Piezometry, lithology and geometry, aquifer characteristics	USGS/USAID exploratory drilling in 1969-74; Irrigation DTWs drilled by BLGWP and other projects
	Deep aquifer monitoring	(probably not available)
Operation data	Data on STW pump sets and operation	GDC farmer interviews; ADBN
	STW drilling, well completion and testing	GDC field interviews with contractors; UNDP/GWRDP district investigation reports
	DTW construction and operation data	BLGWP/Tahal; JADP, BIP

Operational data on STWs are being acquired through a programme of farmer interviews. The first interviews, carried out in February and March 1993, suggest that an expanded programme will give information on the following:

- STW construction defects (sand ingress to well and to discharge, collapse of well head plinth);

- falling well discharge, through slot blockage or sand ingress to the well or through seasonal fall of the watertable which reduces or stops discharge from suction pumps;

- pumpset problems; these seem to include difficulties with pump priming, a consequence of water levels approaching the suction limit or excessive head losses/leaks in the pump pipeworks.

In addition, drilling contractors are being interviewed in the field to gain details of current construction practice; the methods of screen material, screen-slot size selection, well development and yield testing are of particular interest as some STW construction is defective.

4.2 Aquifer System

The main Terai is underlain by detrital, alluvial and eluvial sediments which wedge out northwards upon the consolidated folded rocks of the Siwaliks, and thicken southwards towards the Indo-Gangetic plain. Fold and thrust faulting within the Siwaliks and rocks of the Himalayan foothills have produced structurally controlled valleys of the interior Terai, Dang and Deukhuri.

The main Terai comprises the following hydrogeologically significant lithological-depositional units:

- the Bhabar Zone, which consists of coarse eluvial and alluvial sediments deposited as outwash fans at the mountain front where the rivers enter the Terai plain. The width and geometry of the Bhabar zone sediments seem to have been controlled by the flow regime, energy and catchment size of the rivers entering the Terai Plain; the zone is not present everywhere in the Nepal Terai, in particular where Siwalik sediments occur close to the Indian border. The sediments of the Bhabar zone are coarse sand, gravel and cobble deposits which support a very permeable, unconfined aquifer.

  The zone, thought to be the major intake area to the aquifers of the main Terai, is recharged direct from rainfall and from infiltration from the river beds.

- the interior Terai valleys, which are structural basins filled with coarse eluvial and alluvial sediments; in Dang, at least, the valley contains several terrace surfaces developed in older, part cemented alluvium; below these terraces are alluvial tracts of the present river systems. Locally at least, these valley sediments are moderately permeable and have some considerable aquifer potential.

- sediments typical of the Indo-Gangetic floodplain, which underlie the major part of Terai and comprise alluvial clays and silts; also with important but subordinate sand and gravel layers which appear to be products of historic deposition from the rivers which cross the Terai; these rivers contain a coarse bedload material of sands and gravels and are characterised by constant lateral channel shifts.

Northwards and at depth, the sediments of Gangetic type appear to merge with Bhabar type deposits while towards the Indian border, very fine grain sediments predominate in the section. Total thickness of the sediment pile under Terai is not known. We hope that we will be able to inspect logs from a very deep oil exploration borehole recently drilled in the Biratnagar area of the eastern Terai; such logs might indicate a base to the Terai sediments. However, analysis of deeper boreholes drilled under USGS technical control in Bheri, Lumbini, Seti and Mahakali Zones, suggests that no significant permeable material occurs below 200 m (Table 4.2).

Generally, both a deep and a shallow zone aquifer is developed within the Terai sediments. Sand and gravel layers in the shallow zone, although they cannot be correlated over distance, are generally common enough to support productive, unconfined shallow aquifers which can be found in most areas.

Typically, 20-50% screenable sand-gravel is encountered to 46 m depth (46 m is used as a convenient classification limit for shallow tubewells) and such material may exhibit high permeabilities, in the range 20-150 m/d. Locally, this shallow aquifer can be confined, allowing seasonal, free flow artesian discharge from shallow tubewells.

The UNDP-GWRDP shallow aquifer investigation, carried out in all Terai districts between 1987 and 1992, has allowed a much better definition of the shallow aquifer, in terms of thickness and permeability of screenable aquifer,and water level behaviour of the shallow zone.

Where sand and gravel layers occur in the deeper part of the sedimentary profile, (say below 100 m), within confining beds of clay-silt, then they form productive, confined aquifers whose permeabilities may exceed 200 m/d. Many deep exploration bores (such as those drilled under USGS technical control in 1969-74) and deep irrigation tubewells drilled by the Bhairahwa Lumbini project, have encountered artesian heads up to 20 m above ground level, with consequent free flows at ground level.

TABLE 4.2

DEEP AQUIFER LITHOLOGICAL DATA:

Name of test bore	No	TD (m)	Screen (m)	Percentage screenable material within interval (m) 0-50	50-100	100-150	150-200	200-250	250-300	300-350	350-400	400-450
Bheri Zone: Bardia and Banke Districts												
Kamdi	1/5	217	114.3-120	32.3	26.8	11.6	2.4					
Mauda	1/7	207.6	71.6-77.7	6.7	12.2	6.1	23.7					
Jamunaha	2/1	305.8	124.7-132.6	30.5	62.8	62.0	18.3	7.3	38.4			
Kohalpurwa	2/11	457.3	210-216.5	4.8	0.0	9.7	1.0	18.3	4.0	7.9	0.0	3.6
Sainik Gaon	3/1	304.8	43.3-52.4	15.2	40.2	54.0	24.0	9.0	0.0			
Odarapur	3/3	457.3	58.2-64.3	25.0	25.0	12.0	10.9	18.3	28.6	4.0	8.5	0.0
Dhakela	4/4	369	38.1-44.2	29.8	15.8	21.3	0.0	0.0	7.0	12.1		
Taratal	6/2	339	82-86.6	54.8	54.2	0.0	6.1	0.0	0.0			
Seti-Mahakali Zones: Kanchanpur and Kailali Districts												
Basanta	3/1	457.3	47.25-55.35	13.4	23.7	14.6	12.0	5.0	2.0	2.0	0.0	0.0
Sisaiya	3/5	353	175.3-181.4	14.6	2.0	4.0	31.1	6.1	8.0	0.0		
Ganeshpur	3/8	122.2	80.2-85.1	37.8	14.0							
Phulverria	4/1	304.8	77.7-85.3	16.5	21.3	0.0	0.0	0.0	0.0			
Dhabai	4/5	196	90-96	4.2	33.5	7.3	0.0					
Dangari	5/3	127.1	108.8-114.8	20.1	45.7							
Geta	5/7	304.8	85.3-88.4	14.3	17.7	42.0	6.1	1.0	0.0			
Kaspa	6/4	304.8	67.7-70.7	9.0	15.8	0.0	4.2	14.0	1.0			
Bichhuwa	7/6	304.8	87.5-93.7	47.0	37.2	1.0	5.0	1.0	5.0			
Lumbini Zone: Kapilvastu, Rupandehi and Nawalparasi Districts												
Semri	6/6	460.97		31.7	23.2	11.0	6.1	19.5	25.6	1.0	7.9	17.7
Harakpura	2/1	271.34	63.7-69	62.2	12.2	0.0	12.2	11.0				
Swathi	3/5	304.87	191.4-197.5	1.8	13.4	10.9	21.3	9.1	1.0			
Sunwal	3/7	152.4	42.6-45.7	40.8	38.4	30.5						
Sunwal	3/8	304.87	86.2-89.3	36.6	39.6	1.0	1.0	9.0	17.7			
Sitlapur	4/2	243.90	100.6-106.7	12.2	25.0	20.1	7.3					
Paklihawa	5/1	304.87	149.4-152.4	26.2	16.5	1.2	35.4	14.6	1.0			
Driver Tole	5/17	250	94.5-106.7	72.6	64.0	77.4	58.5	59.1				
Jigna	6/1	289.63		27.4	9.1	0.0	1.0	1.0				
Hughla	8/2	300.91	154-156.1	30.5	5.0	14.0	31.1	9.1	6.0			
Chakacouda	9/1	300.30		6.1	6.1	12.2	1.0	1.0	0.0			
Ajigara	12/1	281.45		7.3	0.0	1.0	3.0	0.0				
	avg	296.59		25.0	24.2	15.7	12.4	9.7	8.1	4.5	4.1	5.3

(based on USAID-USGS investigations, 1969-73)

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4.3 Recharge and Discharge

4.3.1 The System

Recharge to the system principally occurs direct from rainfall in the Bhabar zone and by infiltration from the beds of rivers crossing the Bhabar zone; southwards, less significant recharge occurs directly into the shallow zone sediments and through river bed infiltration. Recharge is transferred laterally into the shallow aquifers and to the deep confined zone, whose driving artesian head is maintained by recharge in the higher level Bhabar zone.

Natural discharge from the system takes place by the following mechanisms:

- leakage to the shallow aquifer layers, across leaky aquitards of clay-silt; leakage is 'driven' by the head difference between deep confined layers and the shallow zone;

- spring discharge at the slope break between the Bhabar zone and the Terai proper;

- outflow across the Indian border;

- evapotranspiration and evaporation from the shallow watertable.

Abstraction, either pumped or by artesian free flow, is now a major element in the discharge from the aquifer systems while reductions in the head of the deep artesian aquifer are thought likely to reduce leakage to the shallow zone.

4.3.2 Recharge Estimation

The estimation of aquifer recharge is of some importance, since it must be assumed that:

- the shallow aquifer will ultimately be intensively developed by STWs, and that there may be an upper STW development limit where recharge availability will start to constrain development (through declining dry season water levels which lead to STW discharge-suction problems);

- concurrently, the deep artesian zone will be developed with DTWs; as a consequence of this, leakance recharge from the deep to the shallow aquifer will be reduced.

Since it is likely to be a control on the upper limit of aquifer development, the quantification of recharge to the shallow and deep aquifer is of some importance. Unfortunately, recharge estimation is problematic, since it involves several unquantified elements, principally the value and variation of effective infiltration rates across the recharge intake areas. Actual and potential recharge has been estimated by various project studies and in the reports of the UNDP/GWRDP shallow groundwater investigations; these estimates involve both infiltration estimates, and the calculation of through-flow estimates using piezometric gradient and transmissivities.

The Bhabar zone receives the highest rainfall in the Terai and has the greatest infiltration capacity. Estimates of potential recharge to this zone, generally based only on rainfall recharge, vary from 465 mm (Electrowatt,1984) to 685 mm (an average of zonal values given by Duba, 1982) and to the very high estimate of Tahal who, in their modelling work (BLGWP/Tahal,1992), present a groundwater balance for the Bhabar zone which allows that about 42% of rainfall (over 1 100 mm) reaches the aquifer; this study also considers recharge from streams cross the Bhabar, in addition to rainfall recharge.

Since well hydrographs in the Bhabar zone strongly suggest that the aquifer becomes full and rejects recharge soon after the onset of the monsoon, potential recharge estimates cannot be verified: the solution to this is to monitor annual piezometric hydrographs as abstractions increase with time, and to review recharge on a progressive basis.

Estimates of direct rainfall recharge to the shallow aquifers have been made by several authors, but these vary by a factor of five (124 mm; Kenting 1984 to 644 mm, zonal range value; Duba 1982), and this is inconsistent with rainfall which shows little variation in total from west to east across the Terai. Our work in Bangladesh, using well calibrated groundwater modelling, has demonstrated vertical recharge through Gangetic type soils of 420-500 mm.

In view of the continuing uncertainties in recharge estimation, it is proposed to follow the pattern established in our 1987 work, and adopt an overall recharge value of 600 mm which is taken to include rainfall recharge and leakance from the deep aquifer; a safety factor is applied to this figure, to give a developable recharge of 450 mm. We propose to review this value, with particular reference to the recent BLGWP/Tahal groundwater modelling.

Conceptually sound groundwater models, using plausible data and boundary conditions, and achieving satisfactory calibration against field data, can indicate a credible range of values for recharge, and allow elimination of unsound values.

4.4 Resource Evaluation,Classification and Mapping

The present study in not primarily intended to be a basic groundwater resource evaluation, since all the existing evidence from exploratory drilling, aquifer testing and aquifer development, suggests that the groundwater resource of the Terai is not limiting to development. The main Terai is underlain by aquifers developed in very permeable sand-gravel layers which are actively recharged. Shallow and deep aquifers are widely distributed and in virtually all areas, one or other aquifer is present.

Rather, our task is to review the 1987 aquifer development classification, using recent data on permeability, lithology and watertable depths, to consider the development possibilities for deep and shallow aquifers and to develop an appropriate groundwater development strategy. We will base this on the 1987 strategy classification, post 1987 groundwater development work in the Terai, and the results of the comprehensive UNDP/GWRDB shallow aquifer investigations throughout the Terai.

The groundwater systems in the inner Terai valleys are less well known than is the main Terai and although the UNDP/GWRDB carried out some shallow aquifer investigations there, we will carry out additional field survey, in particular to verify watertable mapping in the inner valleys.

WE propose to review briefly post 1987 results from DTW production drilling, testing and operation by specific project agencies like the BLGWP and BIP. The existing deep aquifer data base is generally adequate for development planning, although some deep exploratory drilling is continuing (notably by GWRDB). DTW design and construction has been evolutionary, as design changes and improvements (such as a change from natural development to gravel pack in BLGWP DTWs) have been incorporated.

The extensive shallow aquifer investigations by UNDP/GWRDB will allow some revision of the design parameters for the aquifer.

New data on two parameters may cause small, but not significant modifications to the 1987 aquifer development classification, namely:

- discharge and specific capacity testing suggests higher shallow aquifer permeabilities (in the range 20-150 m/d) than established up to 1987;

- the UNDP/GWRDB shallow exploratory drilling has provided better data on percentage of aquifer material in the profile.

In addition, there are now mapping of watertable and watertable change for all the Terai; these data will be used, together with minor field checks and sample survey, to update the 1987 groundwater development mapping and specifically, to improve delineation between shallow watertable areas (where suction pumps are appropriate) and areas where DTWs or pitted STWs can be used.

4.5 Well Design and Construction Practices

4.5.1 Deep Tubewells

There is now a considerable amount of experience in DTW construction and operation, particularly from the Bhairahwa-Lumbini (BLGWP) and Birganj (BIP) DTW projects. Discussions on DTW construction and operation with personnel from both these projects, suggest that the following issues need amplification:

- many of the DTWs have been constructed as pump assisted, free flow production wells but the piezometric head in these wells is not being measured. Although their headworks contain an artesian bypass loop, there is no convenient take off point where artesian static head (better termed shut-in head, or the artesian head measured after the well has been shut down for say 12 hours) could be measured.

  Piezometers have been installed near to these DTWs but it is reported by BLGWP staff that the piezometer screens are shallow,and none are within the DTW producing section.

  The piezometric response of the deep aquifer urgently needs to be monitored, not least because there are differing opinions as to whether the system has or has not shown a regional head decline since the start of abstraction in about 1973. We propose to discuss this issue with BLGWP, to see how monitoring might be improved. Two possibilities will be explored, the installation (or tapping) of small diameter pipework into the headworks of some of the artesian DTWs, or the construction of adjacent deep piezometers in the DTW screen zone.

- Within BLGWP, there are some reports of falls in DTW specific capacity (SC) over time, in some cases apparently associated with unacceptably high levels of sand in the discharge; sand content is being controlled to low levels (maximum 10 ppm), particularly because all DTWs in BLGWP Stage II and III wells are being linked to a piped distribution with alfalfa valves. In some of these cases where sand content is high, the project has carried out well redevelopment and pump testing.

  We intend to review all evidence of sand ingress and specific capacity falls, in the context of current well design in BLGWP. We also hope to review the operational performance of production DTWs in the Birganj Irrigation Project.

  Changes in specific capacity with time, which often are indicators of screen clogging, filter breakdown or sand ingress, could be better detected if routine pumping water level measurements were made (at constant production discharges). This is not currently standard practice in BLGWP.

- BLGWP Stage III DTWs are apparently all being screened with 1 mm slot WWRB Johnson Australia screen against a 2.5 - 8 mm gravel pack; the use of a gravel pack, while not strictly demanded by the grading sizes of the formation, was apparently adopted as a conservative measure, after severe sand ingress problems in BLGWP Stage II DTWs. The designers aim for a 3 cm/s screen inflow velocity and are also currently assuming that an installed 18 m screen will (at worst) become 50% clogged, to give about 10 m of effective screen. We think that a review is necessary of the screen-pack design and the practical philosophy behind using much more screen than hydraulically necessary.

  A similar review of DTW design practice will be carried out for the BIP DTWs.

4.5.2 Shallow Tubewells

Shallow tubewells are being constructed by machine and manual methods throughout the Terai, to depths of between 10 and over 50 m.

Manual methods such as Thukwa (manual driving of a slotted casing terminated at a pointed drive spear) are often limited to shallow depths, particularly in cobble-gravel materials. Such materials can also be slow and difficult to drill with machine percussion rigs drilling inside temporary casings.

So far, interviews with both STW owners and with drilling contractors have indicated the following:

- much of the Bhabar Zone and the interior Terai valleys contain aquifers within material which can be difficult to drill, particularly by manual methods. In Deukhuri, drilling difficulty (and ADBN rules on the basis of payment for successful and failed STWs) seems to have discouraged contractors from operating in the district; indeed, some appear to avoid work there and are said to have migrated to easier drilling conditions in the main Terai;

- there are reports of STW failure or discharge decline (these exclude drilling failures where the contractor cannot complete, and the well is abandoned without casing), a consequence of well or pumpset defects.

There is particular evidence of fine sand ingress to STWs, resulting in clogging of slots, a reduction in water column in the STW, and reduction in specific capacity and discharge. We plan to investigate STW construction practice in a field questionnaire for drilling contractors, to check if the following are implicated:

- incorrect screen-slot placement and use of an incorrect screen-slot size;

- use of unstable or mechanically weak or defective screen-slot material;

- inadequate or non-existent well development (critical in the case of STWs drilled with drilling mud/cow dung mixtures).

Apart from the likely variation in ground conditions and in the diligence of contractors, it is just possible that the questions will show which drilling methods can produce the better well completions.

Other important and related ingredients in STW success are aquifer permeability, the watertable depth and its annual variation.

We propose to use the results of the UNDP/GWRDB shallow aquifer investigation to update the tubewell development mapping of 1987; specifically to delineate areas where dry season minimum watertable is appropriate to suction pumpsets. Some check field survey will be carried out where anomalous water levels exist or the existing survey is inadequate.

This mapping is one of the major controls on the location of STW development so that where shallow watertable coincides with suitable permeability in the screen slot zone, STW installations should be of high reliability. The 1987 shallow aquifer classification will be used, subject to minor modification only.

Initial field work has shown some that there exist several problems with pump sets which the farmer may not always be able to solve. As follows:

- it is fairly common to find pumps which can only be primed with great difficulty if at all (even with the addition of mud sleeves and collars to all pipework joints, the use of a temporary cap to the outlet pipe and copious operation and water priming of the hand pumps which are commonly fitted in the suction line). It is apparently not normal practice to fit non-return valves into the suction riser pipe;

  If we discount those cases where the watertable is near suction limit, then the priming problem must be a function of leaks in the pipework or excessive head losses in the system. The use of a suction gauge, temporarily inserted into the pipework, should confirm leakage, while simple maintenance of pipe joints and sealing gaskets would probably solve the priming problem; this needs further study;

- farmers may report declining STW discharge, and this can have several causes. These maybe related to sand ingress to the STW and slot blockage, or to water levels which have declined close to the pump suction limit (whose cause may be related to permeability of slot zone or to seasonal water level decline). In some cases, poor pipework configuration and jointing (and non-return valves if fitted) may generate excessive head losses in the system; these will lead to discharge falling below rated discharge.

We anticipate that the planned, extensive STW survey will allow further investigation of these problems, which could be acting as a significant constraint to timely STW operation.

4.6 Well Costs

We will review current costs of DTW construction, pumps, electrification and associated well head works; this data will be used to review and update the DTW economic optimisation which was done in the 1987 report. Specifically, the optimisation will be to derive optimum DTW depths for least cost water, for different power sources and operation factors and also to investigate the earlier economic preference for pump assist DTWs over artesian free flow production.

The questioning of farmers has suggested that utilisation of DTWs may currently be much below the 1 400 hours per year assumed in the 1987 work, and thus there is some need to redo the economic optimisation exercise.

Current STW well cost and pump set data, including the costs of drilling, casing and development and the sources of STW components, pumpsets and spares, are being compiled from drilling contractor interviews, from private farmers and from the major STW credit agency, the ADBN. The farmer well questionnaire seeks also to find out the availability, sources and cost of spares.

Much STW development has been encouraged by direct credits from the ADBN. This agency also supplies well casings and pumpsets for installation by the contractor, and we will therefore try to find out the extent of any subsidy on these items, and in the price paid by the farmers.

CHAPTER 5

IRRIGATION

5.1 General

Irrigation studies will be concentrated on identifying well site selection needs, target command areas for different well types and capacities, and requirements for irrigation distribution and efficient water management methods which, in conjunction with other related factors, are required to encourage good use of irrigation wells of all sizes.

5.2 Well Utilisation

The sensitivity analysis carried out for the economic assessment of the 1987 strategy study showed, predictably, that the internal rate of return in deep tubewell areas was far more sensitive to changes in actual irrigation coverage than the other assumptions tested such as yield, costs, or benefits; conversely the potential return from efficiently used wells was great.

Under-utilisation of existing minor irrigation facilities has repeatedly caused great concern in the Indo-Gangetic Plain, particularly when seen in the context of plans for rapid expansion of such facilities. This in turn limits the return on investment and overall agricultural production, and also tends to deter poorer farmers who do not see, or at least perceive, the larger returns which result from more effective utilisation. This was noted during our 1987 studies and was suspected to be a significant constraint to expanding STW uptake.

When considering under-utilisation of wells it is important to view the development of a tubewell unit as an integrated process involving a wide variety of technical and non-technical factors such as:

(a) well siting and yield;

(b) farm size;

(c) irrigation distribution systems;

(d) soils and crop choice;

(e) water management;

(f) farmer co-operation/ participation and group organisation/ management/ ownership in the whole process of well location, command area delineation, distribution system design and construction, operation and maintenance;

(g) well reliability and maintenance facilities and the extent of maintenance back-up;

(h) fuel or power availability and ease of pump operation;

(i) agricultural supporting services such as extension and credit;

(j) time since installation and extent of 'learning' within the irrigation group;

(k) socio-economic and landownership problems;

(l) institutional arrangements during implementation and operation;

In 1987 we were surprised to find relatively little sign of water selling within STW schemes; indications from the 1993 field work so far are that the trend towards water selling is increasing; this will be studied further in the extensive STW survey discussed in more detailed in Section 8.2.7.

We will study the various sources of well utilisation data, and relate the results to those constraints identified in our previous experience within nearby countries, our observations in the field, and our discussions with the agencies involved.

We will also examine the temporal build-up in irrigation coverage, and attempt to demonstrate (within the limits of the available data) the extent of the learning curve showing improvements in the utilisation of deep and shallow tubewell units as the farmers concerned gain more experience.

We will then apply the results of the utilisation studies to existing and proposed tubewell facilities, recommend remedial measures where appropriate, and incorporate them in the design of the tubewell irrigation development models discussed in Section 5.1. We will also pay particular attention to any work being done on command area development in both deep tubewell and shallow tubewell areas under the programmes of the ILC groundwater component, IMWUD and others.

5.3 Water Requirements

In formulating the unit area development costs we will review the target command areas selected in the Main Terai, and assess equivalent targets for the inner Terai valleys for deep and shallow tubewell units; these may vary according to soil and crop selection, particularly in the lighter soil areas which are less water efficient under current water management practices.

Accordingly, we will review subsequent water requirement calculations by MPIDN (1990) and any others and look for any improvements in data effecting water use such as evapotranspiration, rainfall, crop coefficients, soil moisture holding capacity, percolation rates and land preparation. We will then process these data to update our estimates of consumptive use and total water requirements for alternative crops and cropping patterns with adjustment for distribution and field application efficiencies (which we will review critically) and different well types. We will pay particular attention to supplementary irrigation requirements for early 'spring' rice.

Irrigation schedules will then be prepared for the chosen cropping patterns and theoretical well target command areas calculated according to pump discharge and daily operating hours. The calculated values will be assessed in the light of actual pump operation and irrigation coverage (allowing for improvements in water management practices), and recommendations made.

5.4 Irrigation Distribution Systems

In order to maximise the benefits from tubewell development technology, it is essential to establish irrigation distribution systems which will bring as large an area effectively into command as possible. It is very important to involve techniques which lie within the capability and materials available to the farmers as far as possible.

The examination of existing distribution systems and associated structures will be a feature of the field studies, particularly in view of the limited extent and poor condition of STW systems and the constraints of unlined systems in DTWs. Piped distribution systems are also of great interest, and recent commissioning of the Bhairahwa Lumbini II pilot piped systems will provide useful insight to design construction and operational issues. In addition, we propose to visit DTWs with alternative designs (radial mains, ring mains and partial piped open channel systems) in Bangladesh and also seek information on the latest progress with piped schemes in Uttar Pradesh.

An assessment will be made of constraints to open channel layout and design in the traditional sense, for example, the existing systems of irregular field boundaries (which sometimes complicate channel alignment), the extensive sub-division of many farmers' landholdings, and topographic irregularities which would affect new well sites in one way or another.

The ability with which Terai farmers can construct their main DTW or STW distribution systems and the extent to which they are able/ prepared to pay for them will also be examined: our experience in Bangladesh has shown that long established farmers themselves are generally well acquainted with the direction that water will flow on their land.

This is based on their knowledge of the drainage patterns from one field to another during the monsoon period. Moreover, their ability to build channels (based on existing plot boundaries) has often been demonstrated.

Provided that wells are sited sensibly, the main constraint to implementing these channel systems would appear to be the lack of involvement and organisation of the many farmers in a scheme (frequently more than one hundred) and the extent of land fragmentation. This argument was supported by the relatively small number of the STW farmers studied during the 1987 sample surveys who had built their own better-than-average open channel systems.

It is further supported by the achievements by Terai farmers in the farmer surface water systems, and by the clear advantage which established Terai farmers have those of their neighbours who have moved to the Terai relatively recently (as discussed in Section 3.5(d).

The experience gained by ISSP, the ILC groundwater component and IMWUD in promoting farmer participation in groundwater projects will be studied closely.

CHAPTER 6

FINANCIAL AND ECONOMIC ASPECTS

6.1 General Approach

The approach to the study's financial and economic analysis will be as set out in the Technical Proposals of February 1992. Three key issues will be covered:

- the comparison and selection of the most suitable of alternative technical approaches to groundwater abstraction and use;

- the financial viability of groundwater exploitation within the practical limits of markets; farmers resources and supporting services sustainable limitations, and

- the need to maximize the economic benefits to Nepal from groundwater development.

The need to develop irrigation in the Terai is clear. Raising output from the sector is critical if the rapidly growing (2.6% to 2.0% in the longer term) population food security and employment needs are to be met and maintained.

Demand projections given in the recent Master Plan for Irrigation (UNDP NEP/85/013/World Bank, 1990) illustrate the need to increase national output of the major crops suitable for Terai conditions by the following proportions between 1986 and 2000; from an increase of 80% for potatoes to 94% for cereals (wheat 85%; rice 89%; maize 118%) to almost 190% for pulses. Output of oilseeds, vegetables and cash crops also will have to be expanded similarly.

Successfully rapid groundwater development will depend, first and foremost, on any programme's ability to satisfy farmers' family consumption levels in kind and to meet their cash needs after meeting both financing and other operating costs. The study analysis will therefore give particular attention to the financial viability of proposals as they affect the farmer, and the financing institution ADBN and HMGN which will incur the financial and human resource costs necessary to promote widespread groundwater development in the Study Area.

The analysis will concentrate on farmers with less than two hectares. By the early 1980s these accounted for between 40 and 70 percent of all holdings (LRMP 1986) across the Development Regions in the Terai.

Both the financial analyses will include the costs of appropriate farmer management systems, and the selection of suitable cropping patterns that can most benefit from year-round irrigation and also are likely to be adopted by farmers given their particulars resources, marketing and social circumstances.

The Government's present support and subsidy levels will have to be examined and taken into account. Various field studies have shown that the former are often available but of dubious or at least very variable effectiveness, and the latter still a substantial cost to HMGN.

6.2 Financial and Economic Assumptions

6.2.1 Introduction

Detailed assumptions for the study analyses will be made during the economist's second input when the results of field surveys and technical appraisals are available and further price, input and output data are available. The following basic assumptions are however expected to remain unaltered, though will need to be quantified.

6.2.2 Prices

Financial prices will be based on present 1993 levels. Where costs have to be updated, national and Terai zone price indices published by the Central Bureau of Statistics will be used. Present financial prices will be inflated or deflated to their future, year 2000 levels in the same ratio as derived from the calculated 1993 and 2000 economic values for the major commodities.

Economic values will be based on the latest available World Bank Commodity Price Forecasts for 1993 and 2000 at constant 1993 values. The latter will be derived using the Manufacturing Unit Value index from the same source applied to the Bank's forecasts.

6.2.3 Exchange Rates

Exchange rates to be used will be decided in June. In early 1993 the official rate was almost Rs 50 to US $ 1.00. The black market rate was about 10% higher, but was reported to be limited in extent and the modest over-valuation may be taken into account in the standard conversion factors (SCF) rather than using a shadow rate. The decision will be based on circumstances in mid 1993.

6.2.4 Economic Conversion Factors

Standard and Construction Conversion Factors (SCF and CCF) will be used to adjust financial prices to economic values to take into account the official under-valuation of foreign exchange (see Section 6.2.3) and general taxes, duties and subsidies relating to imported and exported goods. The SCF will be applied to internal marketing, handling, processing and administrative costs. An SCF of about 0.9 will be used.

The CCF will combine conversion factors for unskilled labour (0.7), imported materials (to be determined) and components of local origin (0.9) in proportion to the mix of these categories in each structure or item of equipment.

6.2.5 Labour and Draught Power

Data on labour, bullock and tractor draught power are being collected in the present field surveys.

There is a significant difference between peak and off-peak rates of payment, and rates for men and women are slightly different, though this is primarily reflected in the rates for different operations performed by each sex.

The figure used in the financial analysis will be weighted to represent the peak and off-peak wage rates but biased to the peak rate when labour is most in demand. The result will therefore be based on four months at the peak rate and eight months at the lower off-peak payment levels.

The rate used in the economic analysis will be based on the same peak and off-peak rates and the following assumptions:

(a) the same four and eight month peak - off-peak weighting used in the financial wage rate calculation;

(b) the peak rate is taken to be equivalent to the opportunity cost of labour;

(c) the opportunity cost of off-peak labour is half the financial rate.

This reflects the greater difficulty in obtaining work at such times. Any lower rate would not take into account the fact that rice and wheat threshing and storage preparation have their own labour demands during a part of the off-peak season, especially at present levels of mechanisation.

The resulting rates will therefore be determined when the survey data are available.

6.2.6 Energy

For costing purposes and the comparison of alternative forms of pumping energy, estimates will be made of the economic and financial prices of electricity and diesel fuel (high speed diesel, or gasoil). These will be long term projected prices, expressed in terms of 1993 constant values (i.e. excluding future inflation). Most of the original information on which the calculations are based is available from the Water and Energy Commission Secretariat (WECS).

The economic costs of electricity for tubewell use have been considered in two parts; the long-run marginal cost of energy per kilowatt hour delivered at the 33 kV/11 Kv substation (i.e. the generation and transmission costs) and the capital and recurrent costs of distribution per kilowatt of pumpset capacity or per tubewell. Distribution costs have to be considered separately because they will vary greatly according to the pattern and level of demand, the density of tubewells, the proximity of transmission lines and other factors.

Recent information from WECS projects that the long term, 1998/99, marginal cost of energy will be Rs 1.83, Rs 2.60 and Rs 5.62 per kWh for high voltage, medium voltage and low voltage customers respectively.

Adjustments to these figures will be made to take the cost of distribution from the 33 kV/11 kV substation to the location of the tubewells proposed by this study into account more closely.

World market prices of petroleum and petroleum products have been unusually low during the past year, and this is probably reflected in the present import and retail prices of fuel in Nepal.

IBRD predicts a price of US $ 13.7 per barrel in the year 2000 (at 1985 constant values), as compared with that of US $ 11.2 forecast for year 1993. In real terms the year 2000 price would be rather higher than at present, but this will be checked in mid 1993. Further information now being collected from WECS will be used to evaluate the economic ex-pump value of diesel fuel for tubewells.

CHAPTER 7

PERCEIVED CONSTRAINTS TO GROUNDWATER IRRIGATION DEVELOPMENT

7.1 General

This objective of this Chapter is to flag certain aspects of the groundwater irrigation sector in Nepal which we believe have constrained development (or will evolve into constraints in future) and which need to be addressed in due course. This exercise has two purposes:

- to focus on topics for particular consideration during the remainder of the study;
- to invite critical comment from interested parties within HMGN and IDA and clarify any aspects which might require particularly sensitive treatment during the strategy development process and associated discussion fora.

Broadly, the topics fall into four categories; technical, agricultural, social and institutional and these are addressed in the sections which follow. We fully appreciate that these interact in various ways, and can rarely be regarded as individually exclusive considerations. Most of these topics can be related to our over-riding concern that most of the tubewell irrigation systems that we have seen appear to operate at utilisation and associated crop production rates which are well below their potential.

7.2 Technical

During the February/ March field work we identified various technical aspects of the standard STW and DTW packages which we associate with low utilisation levels. The most prominent of these are:

(a) DTWs:

- concern about the reliability of electricity;
- the excessively long period required after drilling and well development to design and build distribution systems, install the pump set and commission many wells;

- extreme difficulty in controlling releases from lined channel sections and at division boxes;

- indecision over whether to use natural development around well screens in very coarse aquifers or whether to install a gravel pack;

- a paucity of field channels;

- poor field and plot channel construction standards;

- very small land holdings with extreme parcelisation;

- absence of a collective cropping calendar so that water is delivered on the basis of demand by individual farmers, first-come-first served;

- lack of consistency in water charges levied by DOI;

- frequent turnover of project or DOI appointed and paid well operators, making communication between farmers and the operators more difficult;

- difficulties with obtaining the necessary agricultural inputs on time and at reasonable prices;

- inadequate artesian groundwater monitoring.

- suspected over-design of wells, pump houses and pumping plant.

(b) STWs:

- un-necessary pumping and limited irrigation intensity resulting from poor standards of earthen field and plot channels;

- discontinuities in earthen channel systems resulting from inter-farmer disagreements;

- difficulties with priming surface mounted suction pumps;

- lack of confidence in STW construction practices and in the common STW casing and screen materials;

- a reported general shortage of skilled indigenous drilling artisans;

- rigid payment rules which do not take account of widely varying drilling conditions and depths;

- lengthy and cumbersome procedures for getting credit for well drilling and reported delays in processing loans by ADBN;

- lack of training regarding maintenance and repair despite expressions of real interest in such training;

- water sales at critical periods only, for example for doing paddy seed beds but not good demand for water at other times when farmers rely/ wait for rain or other surface sources without paying. Low profit margin from water sales;

- individual STW owners not keeping any records at all of hours of operation, operating expenditures or other related costs; STW groups however are likely to keep good records and accounts open to examination by members;

- interest in electricity as a power source as the price of diesel rises, (despite the fact that electricity supply is irregular);

- absence of any advice on how to irrigate most efficiently and to avoid (expensive) water losses;

- cash flow difficulties with buying diesel, oil etc while at the same time making loan repayments, especially now that subsidies have been completely eliminated;

- limited crop choices and options and almost a complete absence of agricultural extension relevant to irrigated agriculture; inadequate knowledge or advice of what to grow that will fetch good market prices.

- general community benefit from use of STW pump or STW priming hand pump for drinking water;

Some of these aspects are discussed further in Sections 8.4 and 8.7.

7.3 Agricultural

The constraints that prevent farmers using their land to its most productive extent have several origins. The first is the need for crop security.

Farmers have very little capital to gamble with agricultural production, and consequently they will not use inputs to raise yields unless the crop is first assured. In this regard irrigation is very important since it brings crop security.

Farmers in Nepal, who have access to irrigation, are progressively introducing new technology to crop and animal production, using HYVs and fertilizers, and using machinery and pesticides. In the intensive areas farmers grow two rice crops as well as winter wheat, mustard and so on, and obtain high yields. But in the majority areas of the Terai, where farms are often remote and farm size is relatively large, the adoption of new technology is less vigorously pursued, even on farms with tubewell irrigation. There are several reasons for this, as follow:

(a) Although appropriate high fertilizer responsive HYVs in rice and wheat have been developed for the more intensively farmed areas and farmers are using these and obtaining high yields, there is a need for intermediate, less fertilizer responsive and more aggressive varieties against weeds, for the more extensive farms.

The old variety Masili is in this class but now unfortunately its resistance to blast is breaking down. Before successful extension of new technology can be accomplished, it is necessary to have the correct technology to extend. This is a major constraint and it will be necessary to give considerable support to the research programmes to achieve develop appropriate varieties for the larger farms of the Terai.

(b) The second major problem to the improvement of irrigated farming is the lack of support for the extension services. It is well established that where extension support is given, as for example in the Block Production Programs and in some of the larger irrigation projects, significant yield increases have been achieved. Consequently, it will be necessary to considerably strengthen the extension services to obtain the maximum benefits of irrigation.

(c) Credit is another area of constraint. Many farmers, even in intensively farmed areas, limit their use of HYVs because of lack of cash for fertilizers and seeds. Credit for farm machinery is also a limiting factor, particularly on the larger farms (farms of average size 6 ha and above), where pedestrian tractors would speed up land preparation and allow more timely planting.

(d) Other constraints relate to the use of incorrect farming practices such as the use of manure as a fuel rather than a fertilizer, the absence of row planting and herbicides to facilitate weed control, and the excessive use of broad spectrum insecticides, all requiring increased extension support.

7.4 Social Considerations

7.4.1 General

It is now agreed by irrigation management decision makers in most countries where irrigated agriculture plays an important role, including Nepal, that farmers must be involved from the very beginning in any and all decisions affecting them regarding irrigation. As an outgrowth of this activity, it is now irrigation policy that setting up any groundwater irrigation facilities whatsoever should be "demand driven" and not be based simply on hydrogeological potential. This is discussed further in Appendix III.

In our 1987 studies, we did not always find this to be the case; especially in DOI DTWs. This previously dominant reality is beginning to change now, especially in individually and group owned STWs being hire-purchased through ADBN (and its SFDP). Turnover of DOI DTWs to the farmers in the areas commanded is already beginning. DOI would like to move this process along quickly in order to reduce the associated financial and manpower burden and, (equally importantly) also to improve the utilisation of these assets.

Yet the farmers are being "clever" not to accept the systems before they are set in, what they consider to be, good working order; especially with regard to problems they cannot take care of themselves within their resource or engineering limits. Some of these perceived or claimed short-comings are clearly unreasonable, and the experience gained so far from BLGWP indicates a significant element of negotiation with farmers in the turnover process. By definition, the turnover program requires that projects be completed to farmers' satisfaction before being finally turned over.

The whole process of developing a truly "bottom-up" participatory approach to groundwater development in Nepal is complex and will be addressed in more detail during the study: suffice it to comment simply now that it is difficult, and that DOI clearly recognises that it requires a new type of thinking and approach from professional engineers who's main thrust has been related to the design and supervision of construction of major hydraulic works.

7.4.2 Perceived Social Constraints

The 1987 studies highlighted a number of additional social and socio-economic constraints to more widespread development of groundwater resources; our experience from our recent field work indicates that these still apply:

- water entrepreneurship is still limited; we lack detailed knowledge of why more STW owners do not sell more water; we need to know who they sell it to, for what purpose and price;

- many STW farmers stop short of their full irrigation potential in the dry season;

- what organizational form for agricultural extension will help to bring about a faster transition to higher productivity from the use of groundwater?

- farmers in DTWs need equitable sharing of water during periods of reasonable supply and good rotation systems when water is in short supply;

- by and large, homogeneous groups can be expected to perform better than groups with mixed ethnicity because casts, ethnicity and power/ lack of power tend to go hand in hand;

- long established Terai farmers tend to have a very advantageous depth of knowledge about their land capability, particularly regarding monsoon drainage behaviour; this is manifested by their relative ease in determining water distribution arrangements (as also demonstrated by farmers near surface water sources and their long established canalisation systems).

7.5 Institutional Arrangements

At present there appears to be a circular pattern to accepted or deferred accountability amongst the main agencies involved in the groundwater irrigation sector. In the past it has been too easy for one concerned agency to default on its responsibilities and blame another: if several agencies are involved it is only too easy for a circular accountability linkage to develop and within which no overall accountability can be specified.

In the shallow tubewell irrigation sector it is quite easy to imagine a circular linkage involving DOI, DOA, ADBN and NEA (in the case of electrified STWs) and the newly emerging private sector. The successful take-off of an intensive STW programme will require each of the concerned agencies to be accountable for certain operations, a simplified scope of which **might be** as shown in Table 7.1.

TABLE 7.1

NOTIONAL AGENCY RESPONSIBILITIES FOR SUCCESSFUL STW EXPANSION

Accountability for:	Agency				
	DOI	ADBN	DOA	NEA	Private sector
Credit for STWs and agricultural inputs		Major	Support		Major
Regional STW planning and monitoring	Major	Minor	Minor	Support	
STW technology	Major				Support
Agricultural extension			Major		
Irrigation/ water management training	Major				
Electrification				Major	

It is important to recognise all of these activities as part of an integrated operation, all of which will be jeopardised if one of the line agencies defaults either at national level or within the framework of the District Development Committees. Current agency responsibilities and the way in which they are affected by the new series of government policy statements are discussed further in Appendix III.

CHAPTER 8

SPECIFIC STUDY ASPECTS

8.1 General

The object of this Chapter is to focus on those aspects of the study which for one reason or another require further emphasis or comment than that given in Chapters 2 to 6; also those which respond to the specific questions raised in Chapter 7. A further objective is to raise any future comments on the Terms of Reference and to anticipate any areas which, particularly regarding hydrogeological data, will remain limited in the overall planning base.

8.2 Remaining Field Activities

8.2.1 Extensive STW Survey

The objective of the remaining programme is to interview STW farmers on aspects of the well installation, on aspects of the agricultural and irrigation practice being used on there farms, and upon the sociological issues pertinent to irrigation water management, labour and group operation of land irrigated by STW water.

The survey target is to visit and interview 100 STW farmers/operators, using a field questionnaire which has been developed and tested during our two field trips to the Terai in February/ March 1993. The 100 interviews are to include:

- those of the 20 STW users/owners questioned during the 1987 field work(who can be located: these STWs are located in 11 of the main Terai districts;

- both ADBN supported STWs, and STWs entirely funded/ constructed by private farmers;

- group owned and operated STWs;

The survey will seek to interview a minimum of 5 private STW farmers (which category probably does not exceed 5% of all existing STWs) and a minimum of 20 STW farmer groups, in addition to ADBN supported STWs. It will also interview the women folk concerned with these enterprises.

It has tentatively been decided not to attempt to work in all 21 districts of the Study Area, but rather to group some areas considered as broadly similar or homogeneous, and to work in these grouped areas. All of the interior Terai valley districts (which were not investigated at all in the 1987 survey) will be included, although work in Surkhet will be limited by the almost total absence of groundwater irrigation facilities.

The tentative work areas are as follows:

Far West/ Mid West:	West/ Central:	East:
Kailali-Kanchanpur	Chitwan	Dhanusha
Banke-Bardia	Kapilvastu	Sarlahi
Surkhet	Parsa	Sunsari-Morang
Dangdeukhuri	Sarlahi	Jhapa

In order to revisit the STWs visited in 1987, it will also be necessary to visit the districts of Rupandehi, Bara, Rautahat, Mahottari and Siraha.

It is likely that a field period of 10 weeks will be required to achieve the agricultural/ irrigation/ sociology interview programme, within which period there will be two breaks in Kathmandu, of about one week duration. Programme completion and planning is based on the following assumptions:

- 2 STW interviews per working day; working week of 6 days;
- 10 week programme made up of three field periods of 2-3 weeks duration;
- one 4wd,landrover type vehicle for the duration.

Completion of field work is required by about 4 June, the return date of the agriculturalist, and to allow this to be met, the field work will be started between 25 March and the 1 April.

Within the constraints imposed by the required completion date, considerable operational flexibility will obviously be needed.

The following staff will participate:

(a) Main Survey Team:

Team Leader/Agronomist	Mr S N Vaidya
Sociologist	Mr Devi Gurung
Socio/female issues	Ms Sara Gurung and Ms Usha Gurung
Irrigation Engineer	Mr S L Joshi

8.2.2 Groundwater Survey

Concurrently with the main survey, there will be some field groundwater surveys, including well census and measurements, data collection from DTW projects and interviews with STW drilling contractors. The groundwater work will be logistically independent of the main survey programme.

Specific objectives of the groundwater work are to carry out a census of STW and dug well water levels, and collect any other information on DTWs, in the Dang and Surkhet areas. Interviews will also be carried out with drilling contractors when these can be located in the field; it is hoped to question both manual drillers (sludging/Bogi method, Thukwa method) and machine percussion or rotary drillers.

It is likely that a minimum 3 week field period will be required to complete work in Dang and Surkhet. Details and location of other groundwater activities are to be finalised.

The following staff will participate in the groundwater work:

Hydrogeologist	Mr K C Keshab (EAST)
Hydrogeologist	Mr S C Amatya (DOI)
part time supervision	Mr S R Uprety (DOI stationed at BLGWP)

8.3 Shallow Aquifer Analysis and Mapping

There are two main objectives:

- to review the 1987 groundwater development classification using recent data from STW (and DTW) drilling, testing and field survey;
- to review/modify the 1987 development mapping, principally on the basis of recent shallow aquifer surveys in Terai.

In 1986-87, little water level data existed on the shallow aquifer in Terai and in order to allow preliminary mapping of groundwater development areas (GDC 1987), an end-of-season watertable survey was carried out by GWRDB; 40-60 water points were sampled in each district.

Subsequently, an extended, shallow aquifer investigation was carried out by UNDP/GWRDB between 1987 and 1992; the results are available in district investigation reports.

Crucially, these contain dry season watertable mapping, and water level change mapping, for the entire Terai. The UNDP/GWRDB has also consolidated water level mapping into a report entitled 'Shallow Watertable Fluctuation Maps, 1987-89. We have two general observations about this work:

- The UNDP/GWRDB water level data has been plotted using machine contouring software; because of the logic of such contouring methods, some of the contour form appears improbable while some clearly anomalous data values have been contoured;

- data values used in some areas, particularly in the Dang Valley, do not accord with recent field observations; water level mapping in Dang suggests virtually no STWs can operate, while this is certainly not so.

To verify various apparent anomalies, we propose to carry out some limited field water level measurement in April- May; much of this work is likely to be in Dang Valley and Surkhet.

Principally on the basis of this work, we will carry out an update/ review of the 1987 groundwater development area mapping (post-1987 data from DTW exploration and production drilling will also be used concurrently to check the DTW aquifer class delineation.

8.4 Well Design and Construction and Practices

We intend to carry out a brief review of DTW design and construction practice, to cover several issues discussed in Section 4.5, as follows;

- review reports of specific capacity (SC) falls, and sand ingress, in BLGWP DTWs and their possible association with current DTW well design, completion and development method; SC or discharge changes with time could indicate screen clogging, filter breakdown or sand ingress. We also hope to examine the performance of production DTWs in BIP, where early operational problems required some DTWs to be re-drilled.

- review current BLGWP Stage III DTW design; the design uses 1 mm slot wire wound screen against a 2.5 - 8 mm gravel pack (the formation characteristics do not obviously require a pack) while more screen is installed than necessary from hydraulic design considerations. These design rules, while apparently conservative, may be related to practical matters of field design procedures; a similar review of DTW design practice will be carried out for the BIP DTWs.

- monitoring and reporting requirements, particularly with respect to the behaviour of the deep artesian system. Data are needed on system response to abstractions, specifically to allow design decisions on the choice between use of free flow or pump assisted DTW installations.

A review will be made of methods of drilling and completion of STWs, with the object of identifying the source of faults in their construction. The review will include an update of costs of STW drilling and casing-screen materials in common use. It is expected that enquiries at the ADBN, the extensive field survey, and the drilling contractor questionnaire, will indicate which casing and screen materials are in current use in STWs, and any defective practices. These could include the following:

- incorrect screen-slot placement and use of an incorrect screen-slot size;

- use of unstable or mechanically weak or defective screen-slot material;

- inadequate or non-existent well development (critical in the case of STWs drilled with drilling mud/ cow dung mixtures);

On the basis of responses from a sample of drilling contractors, it may be possible to suggest generally the optimum drilling method for the different ground conditions found in Terai; this is important since there is evidence that drilling methods are in some areas mismatched to lithologic conditions and this maybe reflected in a scarcity of contractor capacity in some areas.

8.5 Drainage Studies

Our thinking to date has been that extensive STW groundwater irrigation development can only have a beneficial effect on the shallow agriculture system, that the net returns to the system due to deep percolation should be less than the abstracted quantities by the sum of the water lost to the atmosphere through crop evapotranspiration. Moreover the conditions in the depressional soils would probably remain as before - unsuitable for wheat cultivation due to excessive soil moisture at planting/ germination time.

The position with pumping from the deeper, confined aquifer, is less clear; it might be possible to produce a net rise in shallow watertable if surplus irrigation water pumped from lower productive aquifer material is able to raise the shallow end-rainy season water levels to saturate erstwhile well drained soil profiles, reducing the input for wheat cultivation.

This condition could be exacerbated by uncontrolled flowing artesian flows from DTWs throughout the year.

It is tempting to assume that engineering studies to such conditions would not be viable; even if the topography allowed surface drainage system to work effectively how could the drainage water be removed? Pumping solutions would not be prudent either from the point of view of cost, practicability or cost recovery. Thus as far as groundwater irrigation strategy is concerned, the logical conclusion would be to assume that the system would be self regulating, and that the crop system for the existing depressional land should be tailored accordingly (i.e. recognises the non-suitability of wheat).

However, during our 1987 field work in the Bhairahwa area we noted complaints from farmers that the extent of end-monsoon period water logging was increasing; moreover, BLGWP has a programme of installing surface drains. We believe that we should study this more closely, examining actual sample areas with good topographical data to relate well location, irrigation area, and drainage lines to river or stream levels at the interfluve edges. Accordingly, we have recommended in Section 9.3 a revision of expatriate staffing levels to allow a two week input by a surface water drainage engineer.

This work would be based on actual drainage work done in Bhairahwa and we would seek the best topographical data that are available to support this study. The results should provide insight into future surface water drainage needs (if any) and enable a more objective and qualified view on future control of free flowing artesian wells - both deep and shallow.

8.6 Agronomy

The main objectives of the agricultural studies are to assess the impact of tubewell irrigation on cropping patterns, the use of inputs and productivity of tubewell farmers, to consider various development alternatives and to develop appropriate farming models for the various conditions and farming classes encountered in the Terai and the inner Terai valleys. A secondary but important objective will be to assess the strengths and weaknesses of the institutional sector, particularly at the field extension and research levels and to propose strengthening where required. Attention will also be given to assessing the various research programs on crops and crop management in the Terai and commenting on the development of appropriate research and research extension activities.

Information on agriculture will be gathered by questionnaire from 100 tubewell farmers (as discussed in Section 8.2), by interviews with key individuals , by visits to institutional facilities, by reference to National statistics and by the review of appropriate reports and field surveys. Farmers questionnaires will cover physical parameters of the farms, and will obtain estimates of crop yields and cropping patterns and intensities for the "before" and "after tubewell" conditions by farmer recall, and (on cropping constraints and problems) by observation and interview. Verification of current yields will be obtained, where possible, by quadrat sampling during field visits.

The agricultural studies will also cover land use and land suitability for cropping under tubewell irrigation and will produce land use, land capability and land system maps appropriate to assessment of tubewell potential. The agricultural studies will also consider the following matters:

(a) data for land mapping;
(b) crop models;
(c) institutional strengthening:
- adaptive research;
- extension support;

(d) farming practices:
- herbicides;
- row planting;

(e) credit
(f) rice varieties for extensive farming;
(g) winter rice.

Irrigation has a very important place in the improvement of agriculture which is not only related to the supply of water, which naturally improves the growth of crops.

Equally important is the insurance that irrigation brings against crop loss. It is this last factor that disposes farmers to consider aspects of improved farming that would normally not be conceivable.

Improved agriculture also involves peripheral activities such as livestock improvement. An important aspect of improved farming in many parts of the Terai would be the provision of woodlot to reduce the use of dung cakes for burning.

In some areas there are denuded hills surrounding the cultivated valleys where not only lack of fire wood, but also soil erosion is leading to problems of canal silting. These secondary issues will also be discussed in the agriculture report.

8.7 Sociological Research strategy

Because the 1987 studies did not include visits to the Inner Terai valleys (Chitwan, Nawalparasi, Dang, Deukhuri and Surkhet), early visits to these locations became an important part of our reconnaissance field work.

Adaptations and additions to previously used questionnaire materials have been made by a reconnaissance field team composed of an irrigation engineer, a hydrogeologist, an agronomist and a sociologist, each accompanied by a Nepali colleague trained in the same disciplines. The approach taken by this team was a modified rapid rural appraisal, in which specialists worked to collect technical and social information from the same units, along with more specialized inquiries; debriefing sessions were held in the evenings to share and discuss the information which they had obtained. In addition, several HMGN agency offices were also visited, and open-ended interviews were conducted. These included DOI and GWRDP project offices, ADBN regional and district officials, DOA District and agricultural service centres, DDCs and VDCs, and ADOs.

Questionnaires were then given final revision (as presented in their revised form in Appendix II). These forms will provide the basis for the extensive STW survey introduced in Section 8.2. It has also been decided to add a WID (Women in Development) field technician to the survey team, and to develop a set of questions for the wives of farmers being interviewed. Although not specifically specified in the TOR, we believe that these aspects should be considered as part of thew overall farming system. We have also recommended a two week input by a well qualifies Nepali WID specialist in order to interpret the results of this work and place it in a suitable agricultural framework.

8.8 Tubewell Electrification Studies

New 132 kV lines now feed centrally generated hydropower to much of the Terai and have alleviated the earlier dependency on electricity imported from India.

There are clear commitments to provide rural electrification to parts of eight of the Terai districts under the 7th Power Project, now being implemented. Moreover, priority has been given to energising irrigation pumpsets in the Terai although NEA admits to lack of experience at this level and the need to resolve tariff issues.

However, as a result of the extensive expansion of the power transmission and distribution facilities, there are clear indications that the ensuing increase in power connections (and hence countrywide electricity consumption) has outstripped the available power generation capacity. There is a daily countrywide load shedding programme and power is once more being imported from India.

It is not yet clear how indigenous hydro-power generation capacity has been constrained by the late, and low rainfall in 1992, but load shedding will have affected on the Terai districts throughout the 1992/93 winter and subsequent pumping seasons. Some districts may have benefitted from more continuous supplies from India. So far NEA's load shedding programme has been clearly publicised and limited to alternating morning and evening periods of up to three hours. At current levels of pump utilisation this represent more of a nuisance value rather than a serious constraint: farmers still claim to prefer electric rather than diesel driven pumps. We will examine this position further, considering the best information we can gather on both the future increase of generation and distribution facilities. Our energy studies associated with groundwater irrigation development and the choice between diesel and electric drive will examine the following aspects:

- the relative costs of electricity and diesel fuel;
- the availability and extent of the rural electricity supplies (much of the rural electrification is single phase and this may not be adequate for the larger pumps);
- security of fuel supply (most electricity is from indigenous hydro; diesel fuel is imported);
- the availability of local infrastructure to provide maintenance;
- NEA's ability to supply demand from nationally available generation;
- institutional factors, and the organisation set up to develop the groundwater resources.

Our work plan then will be to:

- collect data on the availability and price of electricity and diesel, including the 'strength' of the rural distribution network to withstand pump starts;

- make field visits to a limited sample of sites to judge the suitability of the infrastructure to maintain the equipment;

- evaluate the overall power and energy requirements for developed pumping load;

- calculate costs for individual installations and overall, using financial costs and shadow prices to reflect bias against foreign exchange;

- assess the effect on NEA operations and plans if wide-scale electric drive is chosen;

- suggest arrangements (if any) for supporting the agricultural sector in encouraging irrigation without introducing distortions to the economy;

- draw conclusions as to the most appropriate drive for a number of typical sites and from these. draw overall conclusions as to the impact on the energy sector.

Constraints to power supply systems, such as frequent load shedding, voltage fluctuations, and vulnerability to system faults, will be studied; corrective measures and their associated costs will be discussed with NEA.

For development areas where power supply is inadequate but transmission or distribution systems are located nearby, we will consider linking up the development areas with the distribution systems by extending the latter or installing step-down power facilities to connect the areas with the transmission lines.

We will also compare the total net present value of electric and diesel pump prime movers (including capital and recurrent costs) and use this to estimate the savings gained from using electric drive pumps, and which could contribute to the costs of new distribution systems for tubewell schemes.

In preparing our recommendations, we will consider NEA's overall expansion plans as these affect power supply in the groundwater development areas.

8.9 Conjunctive Use

Situations where tubewell irrigation in one form or another is expected to make an impact on Terai agriculture are sketched on Figure 8.1. This illustrates the possibilities for conjunctive use of groundwater within surface water schemes. Our preliminary field work has indicated that we greatly under-estimated the extent of farmer built irrigation schemes in 1987. These have subsequently be mapped for WECS by local consultants and are clearly of considerable importance (both because they reduce the total area of truly rainfed land and because the farmers concerned appear to have well developed water management skills such as not found in rainfed areas or amongst farmers newly arrived from the hills.

We will analyse both STW and DTW models with specific reference to conjunctive use, and will address the two main distribution system alternatives:

(a) large capacity 'augmentation' wells feeding directly into existing secondary or tertiary canals;

(b) independent tubewell distribution systems (from DTWs or STWs) within areas which are able to receive surface water when available.

In addition to technical and operational aspects, our work will be based on careful assessment of the incremental benefit (in increased intensity and yield) both to the nation and to the farmers concerned resulting from the groundwater component. We will also compare surface water, groundwater and conjunctive development costs on a total production per hectare basis as well as the more usual capital costs per hectare in order to illustrate the impact of conjunctive use in a more constructive way.

We will also address the operation and maintenance costs and associated farmer repayment needs for running public sector augmentation well and the extent to which farmers can participate in the planning, execution and operation of such facilities.

8.10 Regional Groundwater Irrigation Development Studies

In 1987 we made brief visits to India and Bangladesh to assess experience in the groundwater irrigation sector which might be useful in developing the Terai. We propose to adopt the same procedure and, once again, to extend the Bangladesh visit to a study tour to enable our DOI counterparts to see and discuss groundwater development there for themselves.

At present we propose to concentrate the Indian studies on the World Bank office at New Delhi, and request assistance from Bank personnel there, both for commentary on the Bank's ongoing projects and views/experience and with providing the relevant Staff Appraisal Reports and other documents which they are able to make available. We will also examine the possibility of visit one or more of the major tubewell projects in states bordering India such as Uttar Pradesh or West Bengal. We would be seeking experience relating to the planning, design, installation, operation and maintenance of tubewell irrigation schemes; in particular approaches to farmer participation, technical design criteria, well ownership, subsidies and operation support, and the role of electrification. We will seek to update ourselves on the utilisation and management of the buried pipe systems with dedicated power lines in UP and the more pragmatic approach to development reported in West Bengal.

We know Bangladesh to be a state of change, with current government policy heavily weighted towards increasing private sector involvement in both DTW and STW development, increasing farmer ownership and reducing the public sector's recurrent cost burden. We propose to visit our colleagues in Dhaka to discuss these moves, together with progress with private sector tubewell operation through the Grameen Bank and various NGOs, and other field level achievements in water distribution, water management and crop production noted at the IDA DTWs II and the ongoing tubewell projects. The proposals for reduced subsidies and for the wider range of forced mode and suction mode arrangements with STWs, deep set STWs (in pits) and DTWs will be of considerable interest.

Equally importantly, we will compare STW design, materials and installation practices with these in Nepal, looking for ways in which Nepali practices might be improved.

We will also request information from our colleagues working on groundwater injection or drainage projects in Pakistan, and will investigate the current state of the SCARP Transition projects (aimed at reducing the responsibilities of the Government for operating and maintaining drainage wells).

This information will be used to update the regional groundwater focus, and also to compare views and experience on regulating or controlling groundwater development and associated institutional/legal aspects.

8.11 Strategy Formation

8.11.1 Framework for Sustainable Groundwater Irrigation Development

The concept of sustainability in the context of groundwater irrigation in the Terai involves two distinctly different parties:

- sustainability of the government effort in installing and, probably more importantly, containing the burden of operating and managing groundwater within acceptable resource and costs limits;

- sustainability of the farmers' ability to finance, operate, maintain and manage tubewell schemes and to release the financial returns needed both to retain their interest and to repay associated loans.

Clearly, these are not mutually exclusive, and it can be argued that DTW irrigation - essentially public sector driven to date - has suffered because of a gross imbalance in the former; also that STW irrigation - mainly private sector driven to date - has suffered, or at least been constrained, by the second.

Great concern about the public sector burden - clearly visible within the DTW sectors in India, Bangladesh and Pakistan as well as Nepal - has led to increased pressure on reducing government commitments; lowering subsidies, transferring management to farmers, strengthening private sector maintenance capability, privatising well installation operations, and involving farmers in the process of siting wells, defining command areas and designing/installing distribution systems as far as is possible.

This can occur effectively if:

- the whole process of expanding farmer participation and (often) ownership or part ownership of the irrigation assets can be implemented;

- there is confidence amongst the farmers about the financial viability of the venture;

- private sector services are capable of delivering support adequately, at affordable prices, and on time;

- The public sector has adequate resources to deliver those services still assigned to it, including technical assistance.

As already discussed in Chapter 7, HMGN has taken a firm position regarding the expansion of farmer participation as a key means of realising rapid increases in irrigation coverage and of moving resources towards demand-driven development. This concept is manifestly clear current irrigation policy, which is discussed in mor detail in Appendix III. New concepts are being developed and tested through the ILC groundwater components, ISSP and IMWUD as described in Chapter 3. They involve both DTW AND STWs. The results of these and other programmes such as BLGWP III, will be of considerable importance to the study and our overall assessment of a sustainable groundwater development framework. These programmes relate to the turnover of government assets and responsibilities to farmers and the general process of both concerning public sector resources and harnessing the potential and skills of the farmers themselves. They tend to focus on larger wells and on groups of farmers.

Shallow tubewell development in the Terai has been entirely demand driven, and the signs from historical rates of installation are that the programme is if anything decelerating. This situation has already been discussed in Chapter 3. It is tempting to suggest that it is due in part to the second, third and fourth criteria previously listed:

- farmers are less confident that STW ventures are financially viable;
- private sector well construction capability is inadequate;
- the public sector does not deliver adequate support (to raise profitability through increased irrigation coverage and yields).

This is very simplistic, but the fact of the matter is that the shift to true sustainability will require an overall balance; realistic timetables; the correct technology; designs and equipment fit for purpose; education and training; affordable measures; institutional equilibrium, ownership and social equity; pragmatism where required . We will endeavour to address these issues as realistically and sympathetically as possible. We will consult widely and utilise experience from both within Nepal and outside in developing this aspect of the development strategy.

8.11.2 Groundwater Development Planning Scenarios

The scope for groundwater irrigation development will be determined by overlaying land suitability and hydrogeological maps to delineate high, intermediate and low potential zones and by measuring their areas by district.

These might correspond to:

- good aquifer: good soil;

- marginal aquifer: good soils/good aquifer: marginal soils;

- marginal aquifer: marginal soils/areas of forest or national park.

As aquifer classifications will vary, depending on well type, this will lead to estimates of gross areas and high potential for STWs only, STWs and /or DTW, and DTWs only both within rainfed areas and within surface water schemes. By making assumptions over the practicable densities of DTWs and STW, we can develop estimates of numbers of DTWs and/or STWs (or more specifically wells with forced mode pumps) and corresponding net irrigable areas.

This qualitative assessment will estimate the long term limits, high, intermediate and low priority groundwater development in rainfed and conjunctive use areas. At this stage it might be reasonable to plan on the basis of limiting all DTW development and STW development in conjunctive use areas to high priority areas, whilst expanding the promotion of STWs to areas of intermediate aquifer and good soils; as STW sales are already demand driven their location is not technically controlled except in some cases where the drillers fail to deliver productive well.

Our experience in 1987 showed that extensive parts of the Main Terai, particularly in the Central and Eastern regions, had both high DTW and STW suitability classifications. This immediately opens the debate on which technology to use. Generalised alternative scenarios are:

- restrict to suction mode technology;

- concentrate on forced mode technology, particularly in areas of existing project oriented DTWs;

- develop with suction mode technology initially (for speed and economy) with the intention of transfer to forced mode technology in the longer term (to increase pumped abstractions below limits imposed by suction pumps and increase irrigation coverage);

- free-for-all mixing of STWs and DTWs if the latter also become widely available though farmer purchase, demand driven schemes.

The final choice of technology and rate of development will depend on a variety of related criteria and needs such as:

- demand and other social priorities;
- access, electrification and energy pricing;
- drilling capacity and reliable well technology;
- planning, design, supervision and monitoring capability;
- farmer mobilisation and proven participation mechanism;
- finance, subsidy and credit arrangements;
- DOI's surface irrigation programme;
- agricultural, mechanical and technical supporting services.

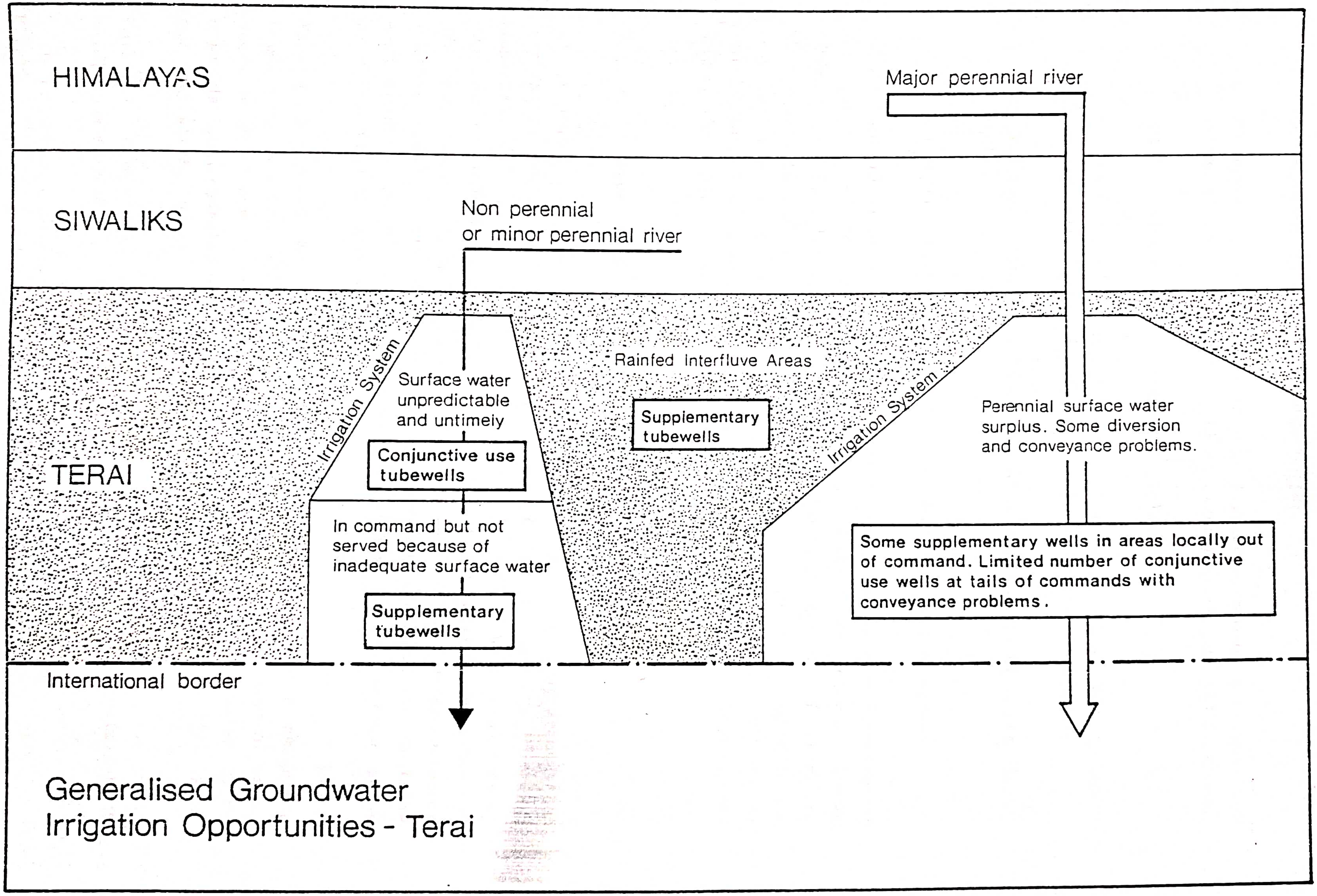
The MPIDN report examined for main scenarios for developing new irrigation areas between 1991 and 2000. These consideration rates of between 3 500 and 7 200 ha per year for DOI groundwater projects (principally forced mode) and between 42 000 and 80 000 ha per year with STWs through the ADBN programme. These accounted for between 25% and 40% of total national irrigation growth.

We will prepare our own groundwater development placing scenarios on the basis of considerations and gathering results from other stages of the study. We will discuss the issues widely. Our overall objective will be to target and phase groundwater development according to technology type and location at sustainable rates, with due regard to programme promotion and planning needs, supporting services and GWRDB's resources.

8.11.3 Resource Conservation

Adverse consequences of resources development and conservation which might follow unregulated groundwater exploitation include:

- conflicts between forced mode and suction mode abstractions;
- regional watertable depletion below suction mode limits which in turn puts STWs out of operation;



Generalised Groundwater
Irrigation Opportunities - Terai

Figure 8.1

- localised drying up of hand pump wells;
- bad publicity for the groundwater irrigation sector resulting from concentration of well installations in marginally justifiable areas;
- depletion of flowing artesian well yields;
- poor performance and low utilisation of wells resulting from inadequate planning, promotion and technical assistance/quality control;
- social equity imbalances (which may also impact on rates of sustainable development);
- soil erosion following removal of sal forest with development.

Related considerations will also be linked to the legal studies discussed in Section 8.11.4. It will be important to distinguish between viewing 'regulation' as a legal issue as opposed to the wider context of control of development through good planning, technical support, publicity and education and monitoring: collectively the objective should be to create a framework for development to occur in a stable and controlled way (even where demand-driven) rather than rely on the legal process.

8.11.4. Legal Studies

At present there is no separate legislation in Nepal governing groundwater irrigation specifically. The Water Resource Act of 1992 is the main legislation which regulates the utilisation of all type of water resources of the country including groundwater. This Act provides legal arrangements for the development, utilisation, preservation and management of water resources whether surface or groundwater or any other sources. This Act also contains provisions to prevent environmental hazards, if any, due to the development or utilisation of water resources.

Major provisions of the Act relating to: ownership rights on water resources, conditions in which water resources can be exploited, organising of water users associations, turning-over of projects or systems to water users organisations, charging of water fees, protection and security of structures and facilities, and setting-up of water quality standards.

This Act is supported by the Irrigation Policy of 1992 and Irrigation Regulation of 1988.

The irrigation policy provides guidelines for the development of the irrigation sector as a whole, i.e. both surface and groundwater. The regulation provides administrative guidelines for the implementation of the Act and the Policy. Major distinguishing features of these documents are that they provide a mechanism for involving water users at each stage of irrigation system development. However, these documents provide guidelines for irrigation development in general and are not specific to groundwater use.

With the extension of groundwater irrigation facilities, separate legislation relating to groundwater irrigation alone may prove to be necessary because the expansion can raise a number of issues not experienced so far. With the increase in groundwater marketing practices, for example, the issues of buyer's water rights will emerge which should be tackled by the new laws.

Issues relating to the rights and privileges of groundwater users, licensing of drilling operations, problems of drainage, obligations of water users associations etc. are bound to emerge eventually with further expansion of groundwater facilities. It is therefore felt that present legal gaps in groundwater irrigation development will have to be studied in-depth with the primary objective of providing guidelines for drafting a new legislation on groundwater irrigation development alone.

We will review the rights and privileges of groundwater users in the development areas under existing laws, and the licensing of drilling and abstraction operators including NGOs, as well as the legal side of acquiring wells, organising water user associations, and transferring public tubewells to water user owned/managed control.

The legal consequences of these recommendations will then be explained and we will address the legal, statutory, and regulatory powers that the relevant governing bodies should have to enforce the rules and, if necessary, penalise non-observance. Our comments will also be given in the light of the attitude of prospective users to ownership of water, farmer participation (and all this involves) and to financial obligations, since this attitude will determine acceptability and willingness to adhere to the regulations.

8.11.5 Strategy Development

The preparation of the groundwater irrigation strategy would be developed from the workable options defined and analyses during the combined activities described in earlier parts of the section, and the zoning of aquifer and land types, according to the various relevant criteria (which would be mapped).

The work programme (discussed in detail in Chapter 9) is planned so that the basic technical and institutional discussion can be presented in mid-study (the subject of the proposed Strategy Formulation Report). This will enable invaluable comment and direction from DOI and other concerned agencies at the beginning of the final strategy preparation phase, focused though the proposed participatory workshop in Kathmandu described in Section 8.12.

Our strategy will also include recommendations for future development priorities including any specific further study needs, a phased development plan, possible project packages and an indication of associated funding needs. We would also look for opportunities for bilateral funding support.

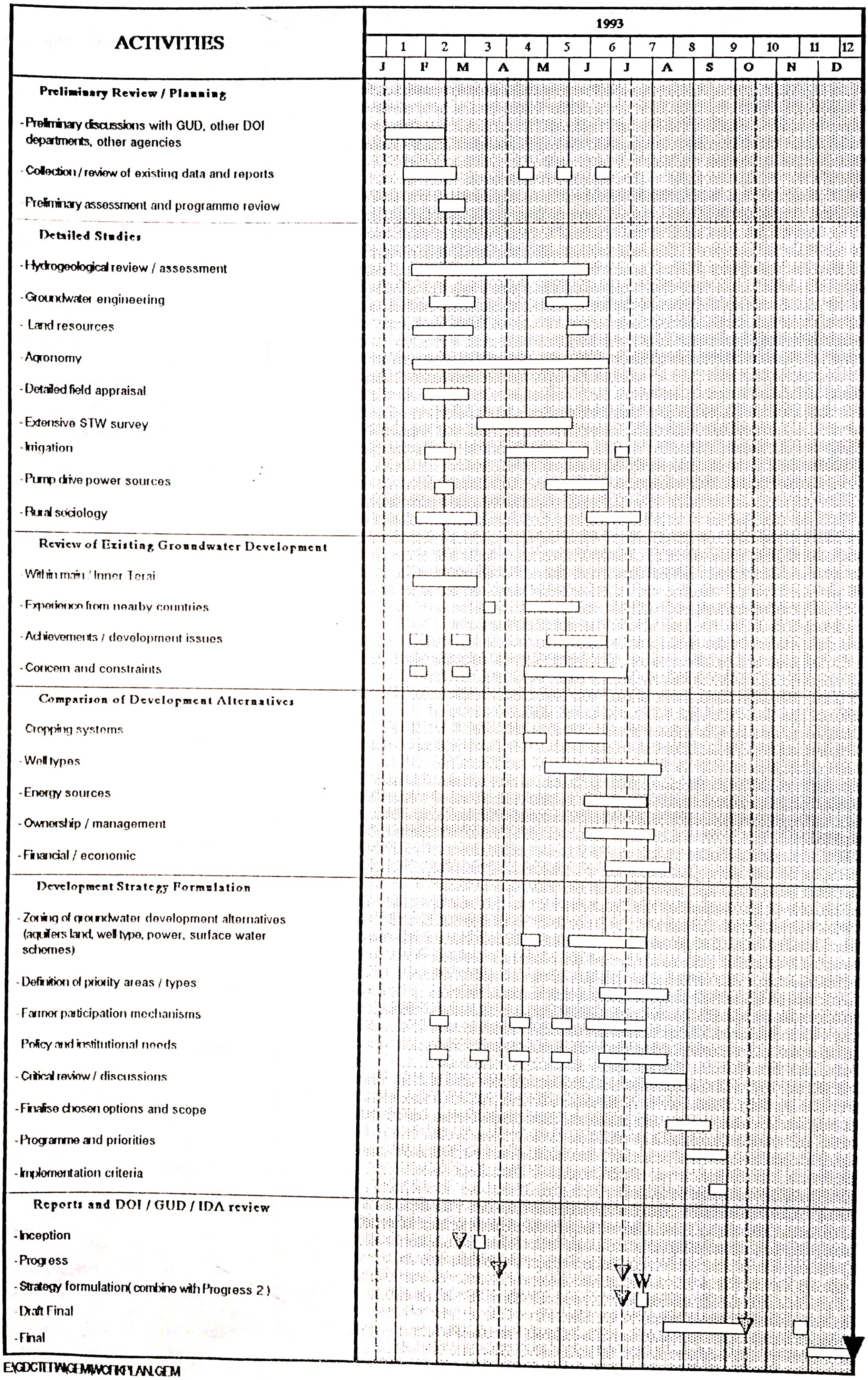
8.12 Consultation and Workshop

In our proposal, we undertook to supplement the second Quarterly Report with a discussion paper on our initial groundwater strategy development findings. The purpose of the paper was to centralize review and discussion on our approach to the final stage of the study. Our contract has budget provision for a strategy development workshop to be held in Kathmandu, and we propose to hold this on or around 1st of August 1993 - some 14 days after the due date for the second Quarterly Report (17 July 1993).

We see this as a valuable opportunity to generate feedback and critical comment on our strategy development proposals and associated technical and institutional frameworks. The workshop will be highly participatory, and we will welcome as many concerned people as can attend, including representatives from the World Bank and any other donor agencies which the DOI might wish to invite. We now take the opportunity, both to invite views on the best draft and format for the workshop, and also to fix the dates and list of participants. We have provision in our contract for Mr R F Stoner, head of the Institute of Irrigation Studies at Southampton University in England to conduct the workshop and to write up the findings. We intend that these proceedings will clarify and confirm the direction which our final strategy development and associated analyses will take.

Figure 9.1

Work Schedule



EXGDCTITTWGEMWORKPLAN.GEM

Figure 9.2

Manpower Schedule

(A) OUTLINE ACTIVITIES

1993: 1 J, 2 F, 3 M, 4 A, 5 M, 6 J, 7 J, 8 A, 9 S, O, 12 D/J

- Review / inception report
- Field work
- Detailed data collection / analysis
- Criteria development
- Development planning studies
- Project analysis
- Draft final report preparation
- Report finalisation

(B) STAFFING

Position	Name	Staff Months GDC Nepal	Staff Months GDC U.K	Staff Months EAST
Study Coordinator/Irrg. Eng	R. Cullen	8.5	0.5	
Irrigation Engineer	S.N.P.Gupta			2.25
Groundwater Devt. Specialist	R. Farbridge	5.5	0.5	
Hydrogeologist	Keshab KC			4.0
Agronomist 1	C.N.Williams	2.5	0	
Agronomist 2	S.N.Vaidya			5.0
Power Engineer 1	L Pope	1.0	0	
Power Engineer 2	C. Bickram			2.0
Sociologist 1	P. Kaplan	2.0	0	
Sociologist 2	K. Koirala			3.5
Economist 1	A.E.Watkins	3.0	0	
Economist 2	S.K. Upadhaya			3.0
Legal Specialist	I.C. Sharma			0.5
Director/ Development Specialist	P.C Joshi			1.0
Panel of Experts/ Specialist back-up	R.Stoner	0.4		
	C.Finney			
	C. Jones	1.0	0.2	
	W.Bakiewicz			
Director in Charge	P. Lee	0	0	
Total		23.9	1.2	21.25

Note: additional 0.5 months each of surface water drainage and women's development specialists proposed in Section 9.3 not shown.

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CHAPTER 9

PROGRAMME, STAFFING, ADMINISTRATION AND LOGISTICS

9.1 Rationale

The object of this chapter is to review the remaining programme and logistical aspects of the Study in view of our preliminary assessment of the scope of the work and the result of our investigations to date. We propose some minor additions/ modification to the staffing schedule which will enable us to address certain topics more rigorously.

9.2 Programme

The programme is driven by the timing of deliverables set out in Section 20 of the Term of Reference, in particular the Second Quarterly Report (due on 17 July) and the Draft Final Report (due on 17 October 1993). As indicated in Section 8.12, we have identified the Second Quarterly Report and the proposed strategy development supplement as a particular focus for review and feedback prior to the finalisation of the development strategy and associated mapping and analysis. Mid-July is a useful period, in thatit will (just) permit analysis of the extended STW survey data and also enable us to review/ incorporate the findings of Nippón Koei's current feasibility studies in the Birganj area.

The work schedule, modified and expanded from the version in our contract, is shown in Figure 9.1, and indicates the intensification of activities in June/ July following the completion of the STW survey and hydrogeological programmes (which will start shortly) and the overall data collection process. We see no difficulty with submitting the Draft Field Report by the end of the ninth month of the study.

9.3 Staffing

The staffing programme has been reviewed, and is summarised in Figure 9.2. This contains minor changes in the timing of inputs, but no changes in total input duration. We propose two additions. During the inception phase we have identified two additional staffing needs.

These are:

- addition of 0.5 months for an expatriate surface water drainage enineer (discussed in Section 8.5);

- addition of 0.5 months for a Nepali Women's development specialist (discussed in Section 8.7).

The justification for these two new posts has been given in the relevant part of Chapter 8. We now request that their costs be met from the existing contingency funds. We nominate Mr. S. Howarth, who will arrive in Nepal to start a new assignment on April 1. He is excellently qualified to perform this task and we expect to be able to arrange his temporary release from his main assignment to perform the required task. If this is possible there will be no need to provide funds for his mobilisation and air fare.

We have not yet identified a specific lady to advise us on women in development aspects, but are confident that such a person will be available to us in Kathmandu.

All in all, these additional inputs (which are to address new aspects of the study) will involve additional expenditures of about £ 6 500 and Rs 120 000 (47% and 34% of the respective contingency allowances).

DOI has provided a full time Coordinator-cum-Irrigation Engineer and a hydrogeologist as required in Appendix E of our contract.

9.4 Study Tours

We propose to arrange a three or four day visit to Bangladesh in early May to examine progress, technical design and performance, and operational issues in both DTW and STW sectors. This will include the current policy in suction and force-mode development and associated costs and subsidy arrangements. We recommend that the visit team comprises the Study Coordinator and Groundwater Development Specialist from GDC and two or three GWRDP personnel.

We will also correspond with the World Bank in Delhi and our colleagues in Pakistan with the hope of collecting current reports and other documents from them. We also propose that the Study Coordinator stops off in Delhi on his way to or from the UK in May to discuss groundwater matters and development with the World Bank Resident Mission there.

9.5 Equipment and Logistics

As required in Appendix B-3 of our Contract, we have reviewed the list of equipment and materials to be procured in the UK, and our revised list is given in Table 9.1. This also includes modification to the locally procured items (notably the deletion of the electric typewriter and the increase in budget for local equipment purchase and hire). We trust that the revised list will be reviewed and approved soon.

DOI has supplied all the computer equipment listed in Appendix E of our Contract except for the laser printer (an A4 width dot matrix has been provided instead). Our revised equipment list includes two new printers and purchase of toner for laser printers for use either in EAST Consult's office or at GWRDP.

9.6 Final Report Maps

As agreed during contract negotiations, the possible need and funding for full colour specification mapping and a colour summary brochure such as that produced during the 1987 study will be reviewed at the Draft Final Report stage.

TABLE 9.1

TECHNICAL EQUIPMENT LIST

Nr	Item	Original list		Revised list	
		Nr	Cost	Nr	Cost
UK1	Computer software	Sum	£ 400	Sum	£ 200
UK2	Lap top computers	2	£ 1 500	1*	£ 649
2b				1	£ 651
UK3	A3 width dot matrix printer	0	0	1	£ 300
UK4	Bubble jet printer	0	0	1	£ 200
UK5	Computer consumables	Sum	£ 250	Sum	£ 250
UK6	Drawing office equipment and materials, specialist stationery, Letratone etc, misc small items	Sum	£ 500	Sum	£ 300
UK7	Workshop presentation equipment (flip charts etc)	0	0	Sum	£ 100
	Total for UK procurement		£ 2 650		£ 2 650
NP1	Photocopier + consumables for 9 months	1	Rs 250 000	1	Rs 250 000
NP2	Local equipment purchase/ hire (light table, voltage regulators, UPS, well dippers etc)	Sum	Rs 30 000		
2a	Light table				6 000
2b	220V/ 110V transformers**			2	3 350
2c	Volt guard 'spike' protectors			3	2 900
2d	2 way printer selector switch			1	3 000
2e	Quadrat field crop counter			2	210
	Battery UPS				30 000
	Misc other items as required				14 540
	Sub-total				Rs 60 000
NP3	Purchase of maps, photos, photographs, reports etc	Sum	Rs 20 000	Sum	Rs 20 000
NP4	Electric typewriter	1	Rs 30 000	0	0
	Total Rupee procurement		Rs 330 000		Rs 330 000

Notes: * already puchased; ** for 110V computer equipment provided by DOI.

APPENDIX I

TERMS OF REFERENCE

NEPAL
REASSESSMENT OF THE GROUNDWATER DEVELOPMENT STRATEGY FOR IRRIGATION IN THE TERAI

TERMS OF REFERENCE

Background

1. A study was completed in 1987 which aimed to define strategies for development at the groundwater resources of the Terai for irrigation[1]/. However, the scope of the study was limited, particularly with regard to the staffing inputs available for field work for investigation of the hydrogeology of the Terai aquifer system. Moreover, the study was limited to the main Terai zone, and the Inner Terai valleys of Chitwan, Dang and Surkhet were not investigated.

2. A recently completed study, which was supported by UNDP, has compiled a large amount of information on the groundwater conditions in both the main Terai zone and the Inner Terai valleys. As this information was not available when the original strategy study was undertaken, its incorporation could modify some of the conclusions reached by that study. It is therefore proposed to expand and reassess the findings of the original strategy study by inclusion of the information provided by the UNDP study into the data base, and to extend the study area to include the Inner Terai valleys.

3. Responsibility for direction of the study will be with the Department of Irrigation (DOI) of the Ministry of Water Resources (MWR).

Proposed Study and Objectives

4. Using and expanding on the information provided the 1987 strategy study and the work completed with UNDP support, the proposed study would develop an appropriate strategy for development of the groundwater resources of the main Terai and the Inner Terai valleys. The strategy developed would take account of the policy of HMGN that groundwater irrigation facilities should, wherever possible, be designed so that they are suitable for handing over for ownership and management by properly constituted water users associations (WUAs) or farmer irrigation associations (FIAs), or as direct investments by private individuals. In this respect, both the manageability and the affordability of the types of facilities that may be envisaged assume importance. Thus, the study should assess the O&M support requirements of farmer-managed facilities (particularly high discharge wells) and develop a strategy for privatization of O&M support services.

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1 Study of Groundwater Development Strategies for Irrigation in the Terai; Groundwater Development Consultants, Cambridge, UK; 1987.

5. The study will consider the development possibilities of both shallow and deep aquifers. A range of well design discharges with a corresponding range of well command areas will be considered for situations where aquifer conditions permit such choices. Similarly, the alternatives of using 'suction mode' centrifugal pumps and 'force mode' deep set turbine pumps will be considered where these are options. Maps will be developed to depict the spatial distributions of the various types development options. In situations where there is potential for development of both shallow and deep aquifers in any area, the resource development constraints that could be imposed by opting to restrict development to the shallow aquifers would be evaluated. Thus a shorter term strategy could be evolved based on development of shallow tubewell facilities with their lower cost and relatively easy management characteristics, while recognizing that exploitation of the deeper aquifers at higher cost and requiring more sophisticated pumping equipment may be required in the longer term to fully exploit the safe yield of the aquifer system and/or irrigate all the suitable lands.

6. The study will evaluate the various types of irrigation water distribution systems that may be appropriate for the various discharges of tubewells and their associated command areas, including, inter alia, unlined earth channels, lined channels and buried pipe systems. Again, consideration will be given to manageability and affordability of the conveyance systems under farmer group management, as compared to their operational efficiency.

7. The electrical power system and diesel are possible alternatives for energizing the tubewell facilities. The two sources of power will be fully evaluated and recommendations will be made for their uses as appropriate.

8. In formulation of the strategy, the study will take into account all previous experience with various types of groundwater development in Nepal and neighbouring countries in the region. Such an evaluation was carried for the previous strategy study,and the findings will be reviewed and as necessary revised in the light additional information available to the proposed study.

9. The strategy study will address the following specific topics:

(a) an assessment of Nepal's historical rates of groundwater development for irrigation in the study area by tubewell facility type, source of investment funding and spatial distribution;

(b) a comparison of the economic and financial costs and benefits of the various types of tubewell facilities and alternative energy sources;

(c) the impact of limited power availability and power distribution infrastructure as a constraint on groundwater development for irrigation, and a detailed evaluation of the costs, processes and conditions under which greater use could be made of electrical power for energizing tubewell irrigation facilities;

(d) the sustainability of groundwater irrigation development based farmer group owned and managed facilities, the degree to which this type of development can be demand-driven, and the agricultural production impact and equity implications of completely demand-driven private sector groundwater development;

(e) the scope for conjunctive use of groundwater to augment supplies in surface water irrigation systems, and the costs and benefits of such development to the country and to the farmers;

(f) the likely rates a groundwater development under various development scenarios including levels of capital cost subsidies and of energy pricing in the case of mains power supply;

(g) the medium and long term consequences of unregulated groundwater development in terms of resource development, resource conservation and social equity; and

(h) the present legal situation with regard to groundwater development and its ownership, and any legislative requirements which could be applied and would lead to proper conservation of the resource while retaining an acceptable level of social equity.

<u>Duration of the Study</u>

10. The work involved in the study through to completion of the draft Final Report (para 18) would be carried out over a period of nine months starting about October 1991.

<u>Consultants' Staffing</u>

11. The consultants' team for the study would include the following disciplines [2]:

(a) Study Coordinator - Irrigation Engineer (9 manmonths);
(b) Groundwater Development Specialist (~~8~~ 6 manmonths);
(c) Agronomist (~~5~~ 2.5 manmonths);
(d) Power Engineer (~~2~~ 1 manmonths);
(e) Sociologist (~~5~~ 2 manmonths); and
(f) Economist (3 manmonths).

~~Additional disciplines may be included in a consultants' proposal if they are considered to be necessary.~~

12. The <u>Study Coordinator</u> would have overall responsibility for organization of the study including scheduling the visits and specifying the tasks of the other team members. He would have general responsibility for preparation of the required reports according to the specified schedule. He would also contribute to the study in accordance with his specialist discipline.

~~2/ The manmonths shown for each discipline should be regarded as indicative and need not be adhered to in a consultant's proposal.~~

13. The Groundwater Development Specialist would be responsible for the evaluation of the aquifer system, its development potential and alternative development options as outlined under para 5. The specialist would develop designs and cost estimates for various types and discharges of tubewells and their associated pumping equipment; specify the construction technologies for the tubewells; and evaluate operation and maintenance costs.

14. The Agronomist would be responsible for updating the general review of agricultural development on the main Terai zone as presented in 1987 strategy study, expanding this study to cover the Inner Terai valleys, and for relating potential groundwater development to soils and land use capabilities as indicated by the LRMP[1]/. The specialist would review the cropping and agricultural performances of the various types of tubewell facilities on the Terai and Inner Tarai, develop appropriate cropping patterns for the soil types and agro-climatic regions, and estimate the irrigation water requirements for the cropping patterns under the various soil and agro-climatic conditions. The specialist would collect data on crop yields and inputs under rainfed conditions and on the range of tubewell facilities in the study area, considering soil types and agro-climatic conditions, and would develop forecasts of yields for the important crops and their associated inputs under groundwater irrigation. In addition, the specialist would review the situation with regard to all agricultural services (extension, research, input availability, credit, processing, storage and marketing), and comment on the adequacy of these services.

15. The Power Engineer would review the present power development in Nepal and ongoing and future programs for power development in terms of generation, transmission and distribution. The security of the power supply would be investigated, both spatially on the Terai and in the longer term with regard to competing demands. On the basis of the existing and planned power transmission and distribution systems, the Power Engineer would identity and evaluate possible opportunities for use of mains power for energizing tubewell irrigation facilities. The evaluation of the power supply system as a source of energy would be measured against the diesel engine alternative in both economic and financial terms.

16. The Sociologist would evaluate and make recommendations regarding the various forms of tubewell facility ownership and management in the project area, including the facilities developed through FIAs under the Bank assisted Irrigation Line of Credit (ILC) projects.

17. The Economist would be responsible for all economic and financial analyses relating to the study including costs of electrical energy at the well head, diesel at the well head and economic and financial evaluation of various types of tubewell facilities under the various conditions across the study area. The Economist would also review the availability of medium term credit for procurement of tubewell facilities by farmers and farmer groups, and the various means by which the credit is distributed.

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[1] LRMP - the Land Resource Mapping Project of 1986 carried out with Canadian assistance.

Reports *

18. An Inception Report will be submitted for review by DOI and IDA at the end of the second month of the study. Progress reports will be submitted to DOI at three-monthly intervals through the period of the study. A draft Final Report will be submitted for review by DOI and IDA at the end of the last (ninth) month of the study. Taking account of comments received from DOI/GUD and IDA, the Final Report on the study will be submitted to DOI by the end of the third month after completion of the work in Nepal..

Cooperating Government Agencies

19. The prime agency with responsibility for implementing the project will be the DOI. Other agencies that will be available to provide information include the Department of Agriculture, the Water and Energy Commission, the Agricultural Development Bank of Nepal, and the Nepal Electricity Authority.

Counterpart Staffing

20. The proposal for the study should indicate the numbers and disciplines of counterpart staffing anticipated. The actual staffing provided will be negotiated with the selected consultant company.

* NOTE: Thirtyfive copies of the Final Report and ten copies of all other reports (including the draft final report) shall be submitted to DOI.

APPENDIX II

FIELD SURVEY QUESTIONNAIRES

TERAI GROUNDWATER II: IRRIGATION STRATEGIES STUDY

CORE TUBEWELL QUESTION SET

1 LOCATION OF THE WELL AND OWNERSHIP INFORMATION

1.1 ID # EXTRA: Interviewers name

1.2 District DATE: TIME:

1.3 VDC name

1.4 Village name

1.5 Ward number

1.6 Type of well? Dug Shallow ___ Deep

1.7 Who sponsored the well installation?
HMGN ADBN ___ Self ___ Other?______

1.9 Distance to the nearest roadhead? (km)

2A OWNER'S BACKGROUND Individual or family owned tubewells:

2A.1 Owner's name/s

2A.2 Household size # effectively working on the farm
2A.3 Ethnicity Language spoken in the house

2A.4 Land holding size? (bigha)
Owned Rented-in Rented-out

2B GROUP'S BACKGROUND Group owned/operated tubewells

2B.1 Names Chairman Secretary

2B.2 Number in the group

2B.3 Ethnicity Homogeneous , what?
Heterogeneous ,which?

2B.4 Land holding size? (bigha) average owned?
Any Rented-in? Y/N Any Rented-out? Y/N

2B.5 Is this an SFDP group? Yes No

2B.6 Does the group or an individual make decisions about water distribution from the well?

3A DETAILS OF WELL

3A.1 Total well depth? (ft)

3A.2 Pump casing depth?(ft)

3A.3 Screen length? (ft)

3A.4 Well casing diameter? (ins)

3A.5 Screen diameter? (ins)

3A.6 Time taken from drilling to installing the well?

3A.7 Time taken from installing the well to completing canals and structures?

3A.8 Time taken from completing canals and structures to irrigating fields?

3A.9 What were the reasons for delay (if any)?

3A.10 In what Nepali year did pumping actually start?

3A.11 How was the well drilled? machine manually

3A.12 Who did the drilling? Privately hired contractor
Office hired contractor

3A.13 Was the drilling done using water mud ?

3B DETAILS OF PUMPING EQUIPMENT

3B.1 Manufacturers name?

3B.2 Country of manufacture?

3B.3 Motor power (BHP/KW)?

3B.4 Pump rated discharge and head(l/s,m)?

3B.5 Diameter of outlet pipe (ins)?

3B.6 Energy source? elect diesel artesian
(check more than one if appropriate)

4 WELL PERFORMANCE

4.1 How many minutes does it take to prime the pump and start it? ____

4.2 Has priming been a problem? Yes No

4.3 If yes, how is it solved? ____________________

4.4 When the pump on, is the outlet pipe full? Yes __ No___

4.5 If no, what fraction is full? (1/3,1/2,3/4) __

4.6 Has pump discharge/artesian flow been reduced since pumping began? Yes No

4.7 If yes, by what percentage?

4.8 If you know why, give the reasons:____________________

4.9 Does the water flow change after long pumping? Yes __ No___ (over four hours)

4.10 Does the water flow change when comparing the wet and the dry seasons? Yes No

4.11 Is there any evidence of pumping sand? Yes No

4.12 If yes, in which season/s? Rainy __ Dry__

4.13 For how long does this continue?

4.14 Has pumping equipment broken down? Yes__ No__

4.15 If yes, in which season? Rainy__ Dry___

4.16 For how many days? __

4.17 What were the reasons for the breakdown? ____________

4.18 Who did the repairs? ____________

4.19 Were spare parts a problem? Yes No

4.20 If yes, what did you do? ____________________

4.21 What were the costs incurred in the repair of this breakdown? Rs

4.22 Do you know anything about how to repair the pumpset and well? Yes No

4.23 If yes, how did you learn? ____

4.24 If no, do you wish to learn? Yes __ No_

5 IRRIGATION PRACTICES

5A IRRIGATION STRUCTURES

5A.1 Total length of canals from your well? meters/kms
permanent temporary ?

5A.2 Total length of channels ? meters/kms
permanent temporary ?

5A.3 Who decided canal/channel layouts?

5A.4 Are canals completed? Yes No

5A.5 Is the channel network completed? Yes No

5A.6 Are the canals well built? Good Average Poor

5A.7 Are the channels well built? Good Average Poor

5A.8 Are there any distinct canal/channel alignment problems?
Yes No

5A.9 If yes, what?

5A.10 Are there distribution structures? Yes/No

5A.11 If yes, how many? And what kind?

5A.12 How far is it from the well to the farthest irrigated field? meters

5A.13 How long does it take water to reach there? hrs/mins

5A.14 Are there water logging problems? Yes No

5A.15 If yes, are these slight or severe ?

5A.16 Have these gotten worse since pumping started? Yes No

5B AREA COMMANDED

5B.1 Farmers' estimate of actual command area based on present completed channel network)? (ha/bigas)
(if more than one boring do each separately)?

FOR UNCOMPLETED CHANNELS SEE QUESTION 5.4A ABOVE THEN ASK

5B.2 Command area (farmers' estimate based on present uncompleted channel network)? (ha/bigas)
(if more than one boring do each separately)?

5B.3 What is the area now irrigated by the TW? (include all the area, even areas out of the command to which water is sold) area in Has or Bigas

Rainy Season Dry Season

5B.4 Has this area increased, remained the same, or decreased? (circle one) since pumping first began? How?

5B.5 How much additional land can still be irrigated from this well?
(Has/Bigas) in Rainy season Dry season

5C OPERATIONAL DETAILS

5C.1 Has the pump any other use than irrigation from drilled wells? Yes No

5C.2 If yes, what?

5C.3 For how many hours per year is the pump used for these purposes? hrs/yr

5C.4 Which are the peak pumping months?

5C.5 What are the total pumping hours per day in the peak months?

5C.6 What are the low pumping months?

5C.7 What are the total pumping hours per day in these low months?

5C.8 How many hours does the pump actually run in different seasons? Rainy___ Dry___

5C.9 Do you supply water to others without charge? Yes/No

5C.10 If yes, who do you give it to and why?

5C.11 How many hours of water do you give away to others in the different seasons? Rainy___ Dry___

5C.12 Do you sell water? Yes/No

5C.13 If yes, how much do you charge? Rs/hr___

5C.14 What form of payment? Cash In kind In labour ___

5C.15 How many hours of water do you sell in the different seasons? Rainy Dry

5C.16 What is the water selling charge based on? ______

5C.17 Is the price for water uniform throughout the year? Yes/No

5C.18 If no, how does it vary? ______

5C.19 What do you include in your operating costs?
fuel lubricants labour repairs spares other
(tick off any which apply)

5C.20 Price for fuel-- diesel/litre? Rs Elect(/KW hr)

5C.21 Is this energy supply reliable? Yes/No

5C.22 If no, why not? ______

5C.23 Operator's salary, if any? Rs/yr

5C.24 Cost of mobil oil? Rs/litre/yr______

5C.25 Cost of spare parts bought last year? Rs

5C.26 Cost of mechanics' fees last year? Rs______

5C.27 Cost of fuel last year? RS

6 FINANCING AND MANAGEMENT OF TUBEWELLS

6A FINANCING

6A.1 Where did you get the money for the tubewell/s and pumpset?
Savings ADBN loan Private loan Others (you can tick off more than one option)

6A.2 What were the costs for:

Well drilling & installation	Rs
Casing material	Rs
Screen material	Rs
Pumpset	Rs
Total costs	Rs

6A.3 How much money did you borrow for your tubewell and pumpset? Rs

6A.4 What was the interest rate? Public % Private %

6A.5 How long did it take to get the loan? Days______

6A.6 Have you now fully repaid the loan/s? Yes No

6A.7 If you are not up to date with your payments, why not?

______

6B MANAGEMENT OF INDIVIDUALLY OWNED WELLS

6B.1 Who operates the pumpset? Paid operator Owner/self __
Other?

6B.2 Do you know how to operate the pumpset? Yes No

6B.3 If yes, how did you learn?

6B.4 Do you know how to do repairs and maintenance of the well and pumpset? Yes No

6B.5 If yes, how did you learn?

6B.6 If no, would you like to learn? Yes No

6B.7 Do you keep records of:

	Yes	No
hours of operation		
operating expenditures		
other records, what?		

6C MANAGEMENT OF GROUP OWNED WELLS

6C.1 How did this group come into being?

6C.2 When was this group formed? Mo/Yr

6C.3 How does the group pick its executive members?

6C.4 Which of the following functions does the group perform? (tick off any which apply)

Labour mobilization for canal maintenance __
Fee collection
Water distribution
Water conflict resolution
Keeping accounts and records __
Others (specify)

6C.5 How are these aforementioned functions performed?

6C.6 Does the group have any problems in its functioning?
Yes No

6C.7 If yes, what are they?

7 FARMER'S OPINIONS

7.1 What are the most important problems for you in running your irrigation system?

7.2 What are the most important problems for you now, in doing your irrigated agriculture?

7.3 We are working as the ears of HMGN regarding the possible expansion of irrigation from groundwater in the Terai and Inner Terai Valleys. This is your chance to speak on such matters! What do you want to say to HMGN?

8.0 AGRICULTURE

ID#__________

8.1 Land Areas(Biga): Total Farm_____ Khet_____ Bari_____ Rough_____

8.2 Present Cropping Pattern/s

8.3 Before Tubewell Cropping Pattern/s

8.4 Varieties Grown: Rice___________________ Wheat___________________

Maize__________________ Pulses______________ O.Seeds____________________

8.5 Present Crop Details

CROP	AREA Biga	PRODN. kg.	CALENDAR Plt.	Hvst.	FERTILIZERS USED Kg. Urea	20:20	DAP	TSP	Manure
E. Rice									
M.Rice									
Wheat									
Maize									
Oil Seed									
Pulse									
Potato									
Veg.									
S.Cane									

8.6 Crop Details Before Tubewell

CROP	AREA Biga	PRODN. kg.	CALENDAR Plt.	Hvst.	FERTILIZERS USED Kg. Urea	20:20	DAP	TSP	Manure
E. Rice									
M. Rice									
Wheat									
Maize									
Oil Seed									
Pulse									
Potato									
Veg.									
S.Cane									

8.7 Details of Irrigation, Number/Depth cm.

Rice___/_____ Wheat___/_____ Mustard___/_____ Chick Pea___/_____

Spring Maize___/_____ Potato___/_____ S.Cane___/_____

8.8 Methods of Cultivation for Rice (tick)

First Ploughing:	Manual___	Bullock___	MiniTractor___	Tractor___
Second "	Manual___	Bullock___	MiniTractor___	Tractor___
Third "	Manual___	Bullock___	MiniTractor___	Tractor___
Puddling	Manual___	Bullock___	MiniTractor___	Tractor___

No. of Weedings: 0___ 1___ 2___ 3___ 4___

8.9 Methods of Cultivation for Wheat (tick)

First Ploughing:	Manual___	Bullock___	MiniTractor___	Tractor___
Second "	Manual___	Bullock___	MiniTractor___	Tractor___

No. of Weedings: 0___ 1___ 2___ 3___ 4___

8.10 Methods of Cultivation for Pulses/Oil Seeds (Describe):

Mustard ____

Other ____

8.11 Constraints to Cropping: Fill in 1=little or no problem 2=slight problem 3= serious problem

Weeds___ Flooding___ Waterlogging___ Insects___ Disease ___

Rats____ Birds___ Labour___ Inputs___ Credit___ Low Prices___

8.12 Have you had contact with an extension worker in 1992/3 (tick) Yes____ No____

8.13 Quadrat Readings (Av. of Three)

Best Field: No. Heads____ No.Grains_____

Worst Field: No. Heads____ No. Grains____

8.14 Hired Temporary Labour (Man-Days) for Cropping Per Year__________

Full Time Labourers No.______

Payment per day for Temporary Labour(include food) Rp______

Payment per month for Permanent Labour(include food) Rp______

8.15 Cost to hire a pair of bollocks to plough one Biga of land, Rp_________

8.16 Cost to hire a MiniTractor per day, Rp_______

8.17 Cost to hire a big Tractor per hour, Rp_______

9 IRRIGATION SYSTEM (To be completed by an irrigation engineer)

9.1 Realistic command area of the well? Ha/Bigas__

9.2 Actual command with present channels? Ha/Bigas ____

9.3 Fallow areas? Ha/Bigas

9.4 Potential gravity expansion? Yes No

9.5 If yes, Simple extension? ha/bigas/katas __
Complex extension? ha/bigas/katas

9.6 Well location good bad ? Why? ____

9.7 Feeder channels: Total length? Meters
Good Av Poor ?

9.8 Approximate % : > 1 ft fill ;> 1 ft cut ; lined ?

9.9 Any distinct channel alignment problems? Yes__ No___

9.10 If yes, what?

9.11 Field channels: Total length? Meters Good Av Poor

9.12 Feeder channel structures:

Structure Type	Existing #	Type*	Additional req'd Yes	Additional req'd No
Discharge box				
Culverts				
Falls				
Division boxes				
Aqueducts				

* E= earth/timber B=brick C=concrete

9.13 Gates generally made of earth/mud wood metal ?

9.14 Condition-- Good Av Poor Missing ?

DRAW PICTURE OF DISCHARGE SETUP HERE

CHECK LIST FOR RESOURCE POOR FARMERS

1.0 How many kattas of land do you own? Rent-in?

1.1 Do you buy water from a tubewell for irrigation of your fields? Yes/No

1.2 In which season/s and for how many hours each season?
Rainy Dry

1.3 At what price per hour? NRS w/diesel from owner/s
NRS ___ w/your diesel

1.4 Do you consider this water charge rate to be
too costly or just all right

1.5 In what Nepali year did you start to do this? ____

1.6 Do you get the water you buy on time? Y/N

1.7 Is the amount of water available for sale to you enough?
Y/N

1.8 What do you use the water that you buy for? (Tick any which apply)
making early seedbeds for rice
wheat
Maize
oilseeds
pulses
potatoes
vegetables

2.0 Do you plan to install your own borehole
buy your own pumpset ____
individually ____
in a group ____
continue buying water

3.0 Why do you plan to keep on buying water? (probe for answer and tick any which apply)
Non-available of underground water
Not enough land
Risk from being indebted
Management or operation and maintenance difficulties foreseen
Fragmented parcels of land
Costs of diesel and mobil
Others, what? ____________________

* Farmers to be interviewed with this form have to be water buyers who own one or less bigas of land. They could be partial or complete sharecroppers. Only one should be interviewed nearby each STW interviewed. There may not be any!

4.0 If you plan to do a boring or buy a pumpset, how do you plan to do this?

Form a group with neighbouring farmers
Form an SFDP group
Borrowing money from a bank
Borrowing money from private sources
Other, what ____

5.0 If you are sharecropping some or all of the land that you farm, what percentage do you give to the landlord?

Percent of main crop (rice)
Percent of the second crop (wheat,pulses)

6.0 Have your yields increased since you started buying water?
Yes No If yes by what percentage?

Rice
Wheat
Pulses
Vegetables

7.0 If sharecropping, has your share in the increased production
gone up remained the same gone down

8.0 Is there the possibility of other kinds of irrigation besides STWs in your area? Yes No

8.1 If yes, what kind? Surface ____ DTW ____ Lift pumping____

8.2 If electric powered pumping were possible here, would you prefer it to diesel engine powered pumping? Yes ____ No____

8.3 If yes, why? ____

8.4 If no, why not? ____

COMMENTARY: Interviewer try to get a clear picture of problems and perspectives of the resource poor farmer and why he cannot get involved in groundwater development. Also write down in summary form how he thought he might be able to do this>

Drilling Contractor Enquiry

1 General:

1.1 Name of Contractor
1.2 Office/contact address
1.3 Location of work site
1.4 District/VDC/W.No
1.5 Do you have a plan/design before you start?

1.6 Is anything agreed between you and farmer or between you and ADBN?
[price,yield,depth]

2 Drilling:

2.1 What drilling and development tools do you have?
1............. 2............. 3............ 4.................

2.2 Drilling method:
manual: rotary....... Bogi....... Thokuwa/hammer....
sludge/dhikuli......

powered: rotary....... percussion......

2.3 Do you drill:
-until you find so much sand/gravel
-to a fixed depth
-to the depth limit of rig
[cobbles,cemented layer,fine sand]

2.4 What drilling diameters do you use
2.5 What reaming diameters do you use

2.6 Do you drill inside a temporary casing

2.7 Do you drill with water,or do you use mud?

2.8 When do you use mud

2.9 Do you ever use a gravel pack, or just screen

2.10 How much space do you allow if using a gravel pack [drilling - casing diam]

2.11 What drilling fluid do you use
[bentonite,local clay,water,cow dung]

2.12 How long do you take generally take
to drill a 15m STW and a 40m STW

2.13 Which material causes drilling problems
in this area [fine sand, boulders]

2.14 Do you take samples of the formation

2.15 Do you have a technician who examines sample
of formation as you drill

2.16 Who supervises your work

3 Screen

3.1 Where do you obtain screen:ADBN market India

3.2 Do you pick screen size on basis of formation
size; or do you use whatever screen available

3.3 How do you choose screen type and size
[availability,formation size,price]

3.4 What type do you normally use:
[specify if stainless,mild steel or galvanised]

perforated pipe..... perforated pipe,rope wrapped......
perforated pipe,brass net wrapped......

slotted pipe........
slotted pipe,rope wrapped......

Coir wrap on steel rod.........
Nylon net wrap on rod/bamboo cage......

Wirewound,rodbased Johnson type........

3.5 If you have a choice, do you fit screen aperture size
to formation size or always use the same size

3.6 If you could buy several sizes of screen, which would be most
useful sizes for conditions around here
[1/32,1/16,1/8,1/4 in]

4 Gravel Pack

4.1 Do you use a gravel pack
Under what conditions
[fine sand]

4.2 If you use a pack, does it cause any problems

4.3 If you don't use a pack, does that cause any problems

4.4 Do you use pack with you drill with mud

4.5 Do you use pack with you drill with water

4.6 How much annular space do you allow for the pack
[casing to hole diameter]

4.7 What grain size material do you use for the pack
[size in mm or size range]

4.8 Is it graded for size

4.9 How do you add the gravel pack to the well
[tremie]

5 Development

5.1 For how long do you develop a well

5.2 How do you clean-develop well [mud drilled] after drilling
[water,air jetting and air lift pump,detergent,centrifugal pump]

5.3 Do you clean/develop the well if drilled with water only

5.4 How long does well development take

5.5 Do the screens ever get blocked by mud

5.6 If so, what do you do

5.7 If well discharge is very low, do you develop the well more or do you sometimes have to redrill the well

6 Problems

6.1 Do you find problems with sand filling the well
6.2 Why do you think this happens

6.3 Do you find problems with blockage of the screen
6.4 Why do you think this happens

6.5 If the farmer gets fine sand in his well, do you revisit, clean it out and redevelop it

6.6 How do you think the sand enters the well

6.7 Does the screen/slotted pipe ever collapse

6.8 What do you think causes this collapse

7 Costs

7.1 How much do you charge for the drilling, installation and development of a STW

diam in   Rs/m

7.2 How much doy you charge for:

screen:
casing:

7.3 Do you charge on a day work basis or by unit rates for the work

7.4 What are the rates for the following;

(Rs/m)

-drilling 4in diam
-drilling 6in diam
-drilling 8in diam

-reaming to 8in diam

-Development method: (Rs/hour)

-by air compressor
-by air jetting
-by pump
-washing/manual pumping

7.5 What do you estimate to be the total cost of a 15m and a 40m STW in this area (exclude pump set cost but include drilling,casing and development cost)

APPENDIX III

REVIEW OF CURRENT POLICIES AND INSTITUTIONS AFFECTING GROUNDWATER DEVELOPMENT

APPENDIX III

REVIEW OF CURRENT POLICIES AND INSTITUTIONS AFFECTING GROUNDWATER DEVELOPMENT (FIRST DRAFT)

III.1 Introduction

Since the December 1987 study (GDC:1987) some basic changes have taken place in the politics and government in Nepal, which, in turn, have influenced the government's perceptions, priorities and policies toward development. The new government, which is based on adult franchise and parliament and in line with the West-European democracies, have announced new policies in most key development sectors. The major purpose of this paper is to examine these recent changes in the government's policies and institutions and to look for their implications on groundwater irrigation development. Four major policy areas are identified here as relevant areas having more direct bearings on groundwater development: water resource and irrigation development policies, agricultural development policy, energy policy and policies on institutional development. Policies in other areas such as money and public finance, transportation, industry, trade and commerce and environment etc. do influence the course of groundwater irrigation development. However, these are not considered here for review because of time constraint and other limitations.

III.2 Water Resource Development Policy

Nepal is generally considered very rich in water resources both surface and groundwater. There are mainly four major identified areas of water use: drinking water, irrigation, fishery and other agricultural uses and hydro-power generation. Major thrusts of the government's current policies on water resource development are on drinking water, irrigation and power generation. Policies for water resource sector in Nepal are formulated by the National Planning Commission, Nepal (NPC/N) in collaboration with the Ministry of Water Resources, HMG, Nepal (MoWR/HMG/N) and its relevant departments and organs.

These policies are backed by appropriate legislations and regulations for implementation which are drafted by the Ministry of Law and Justice, HMG/N (MoLJ/HMG/N) and the concerned department of the government, which is mainly the Department of Irrigation (DoI) in the context of irrigation development. At present there is no separate legislation in Nepal governing groundwater irrigation development in particular.

Direction for groundwater irrigation development is mainly provided by the national irrigation policy, the relevant provisions of the water resource related acts and the irrigation regulation. Recently, in 1992, the government has announced both a new water resource act and a new national policy for irrigation development which regulates groundwater irrigation development at present and thus included in this review.

III.2.1 Water Resource Act-1992

Before 1992 all water resource development related issues were mainly governed by the Canal, Electricity and Related Water Resources Act-1967 (CERWR). This act contained provisions relating to: ownership of water resources, rights of water use, conditions of acquiring water rights and priorities for using water etc. This act dwelt little on such important issues as: the constitution, power and functions of water users associations and on the provisions of imposing water charges. It was also felt that since the issues relating to utilisation of water resources for power generation and irrigation are different, separate legislations should be enacted to regulate these two different uses of water resources.

To make-up these long felt deficiencies of the CERWR Act the new parliament recently passed two water resource related Acts: Water Resource Act-1992 and Electricity Act-1992. The Water Resource Act-1992 is the main legislation governing the irrigational use of water resources at present including the groundwater irrigation. The preamble of this Act states that "this Act is promulgated to provide legal arrangements for optimal development, utilisation, preservation and management of water resources within Nepal, whether surface or groundwater or any other sources; to prevent any environmental or other negative impacts due to such utilisation of water resources and to keep water resources free from pollution."

The Water Resource Act-1992 is more comprehensive compared to CEWR Act-1967. Its major distinguishing features against the previous Act are: it makes specific recognition of the role of legally constituted water users association in developing and utilising water resources or irrigation facilities including groundwater irrigation facilities and makes provision for turning-over of agency or government owned projects to users. Its concerns for preventing possible environmental hazard and water pollution in course of exploiting water resources are also among its novel features.

III.3 Irrigation Development Policy

The Water Resource Act-1992 is mainly concerned with administering and regulating the development of water resources . Its major purpose is to regulate water resource development according to the national policy guidelines. The policy direction for the irrigation sector is mainly set by the Irrigation Policy 1992, which was again recently approved by parliament.

Major emphases of this new policy are in developing cost effective and sustainable irrigation facilities on a priority basis and in bringing about uniformity of approaches between different agencies in the irrigation development works. One of the major objectives of the policy is to gradually decrease the government's involvement in the construction, operation and maintenance of irrigation schemes by gradually increasing the participation of users or by emphasising the farmer's tradition of constructing and managing irrigation systems in the private sector. The policy also aims at improving the present level of service delivery in irrigation sector by reforming the institutional structure and management system and research and training capabilities of the governmental and non-governmental institutions currently involved in irrigation development. This policy continues to pursue the strategy of turning-over government operated irrigation projects (having the command area up to 500 ha. in the hills and up to 2 000 ha. in the Terai and even bigger projects than these, if feasible) to water users associations. The policy also continues to emphasise the conjunctive use of surface and groundwater sources wherever practicable.

III.3.1 Classification of Irrigation Systems and Cost Sharing Arrangements

The Irrigation Policy-1992 classifies all irrigation systems into four categories on the basis of ownership or management of the systems, which is also among its new features. The policy has also made some changes in the cost sharing arrangements from the previous policy -- the Working Policy on Irrigation - 1988. The new classification of the irrigation systems and the cost sharing arrangements thereof are presented in the following paragraphs:

(a) systems operated by water users;
(b) government systems to be turned-over to farmers;
(c) systems under joint management;
(d) private irrigation systems.

The first category includes those systems which are or will be under the collective ownership of the users.

Collectively owned deep or shallow tubewells will also fall under this category. Such irrigation projects should be initiated only on the basis of demand of the majority of beneficiaries. There shall be full participation of beneficiaries in the planning and implementation of such systems and a legally constituted water users organisation shall eventually, fully bear the operation and maintenance responsibility of such projects. The users shall provide all land required for the construction or rehabilitation of such projects free of cost and they shall also bear certain percentage of total capital cost of the project in labour or cash or both. The minimum percentage of costs to be borne by the users in this category of projects are as follows:

TABLE III.1

Current Cost Sharing Arrangements on Users Operated Groundwater Irrigation Projects

Tubewell Type/Nature of Construction	Cost Sharing (in percentage)	
	HMG's Share	Users Share*
Deep Tubewell		
Rehabilitation	85	15
New Construction	90	10
Community Shallow Tubewell		
Rehabilitation	80	20
New Construction	85	15

* In labour or cash or both.

The second category of projects (see (b) above) are those which are being operated at the government level at present but which will be eventually, turned-over to the users association for operation and maintenance. The turning -over will include both transfer of ownership and management. Under this policy provision there is a programme to turn-over all GWRDB deep tubewells including those in Bhairahwa-Lumbini Groundwater Project (BLGWP).

The new policy requires that before turning-over a project to water users association necessary renovation, rehabilitation or improvements should be undertaken by the government mobilising users participation. For such rehabilitation the concerned water users association shall provide necessary land free of cost and also shall bear five per cent (5 %) of the total costs in labour or cash or both.

The third category project (see (c) above) include larger surface schemes (>500 ha. in the hills and >2 000 ha. in the Terai) and thus does not have much implications for groundwater irrigation development.

The fourth category of irrigation systems (see (d) above) include those which have the command area of less than 25 ha. in the Terai and 10 ha. in the hills, irrespective of the sources of water, whether surface or groundwater, and type of technologies. Private enterprises, autonomous public corporations such as banks and non-governmental organisations will be more actively involved in the promotion and development of these private irrigation systems. Groundwater irrigation, particularly, shallow tubewells of both types of ownership, private and community, have been included by the new policy as private irrigation systems. Under this category shall bear 25 to 60 % of the total costs for shallow tubewells where as the agency which is primarily, the Agricultural Development Bank/Nepal (ADB/N), will bear 40 to 75 % of such costs. Very recently, however, this cost sharing norms have changed (see section III.6).

III.4 Agricultural Development Policy: General

Objectives of all types of irrigation systems are to increase agricultural production and productivity. Prevailing agricultural practices and existing agrarian structure of a country significantly influence the design and efficiency of irrigation systems. The agrarian structure of Nepal is characterised by very small land holdings (average holding size is 1.12 ha.), skewed trend of land distribution (50 % of the total farm families hold only 7% of the total cultivated area where as 4% of the same hold more than 29 % of the total cultivated area where as 4% of the same hold more than 29 %), absentee landlordism or informal tenancy and fragmented land holdings (the average holdings of 1.2 ha. is fragmented into 4.3 parcels). The crop production practices are essentially subsistence-oriented. Rice, wheat, maize, millet and barley are the main agricultural products which are produced for family consumption. Average production of these food grains is very low at 1.7 t/ha. Meanwhile, in the past few decades the country is witnessing declining agricultural productivity combined with rapid growth in population.

Over a period of four decades of planned development efforts the government have been making a consistent attempt to improve the performance of the agricultural sector. The Eighth Plan (1992-97) also accorded highest priority to agricultural sector development. A new policy for agricultural development have recently been announced by the government.

Major thrusts of this policy are on: promoting agricultural production according to agro-ecology of the country, commercialising and diversifying agricultural production on the basis of comparative advantage and export potentials, providing agricultural extension services under an unified structure and mainly, through service centres at the local levels, improving efficiency and effectiveness of extension services, encouraging private sectors in the production and distribution of agricultural inputs like seeds and fertilisers. Simplifying procedures of disbursing agricultural credit, revitalising co-operative movement and training farmer's groups and leaders on improved agricultural practices are among other policy objectives.

While developing agricultural development programmes, the policy document states that priority will be given to those potential areas where resources, transport network and irrigation facilities are already available. For this the entire cultivable land of the country will be classified into irrigated and non-irrigated land and intensive agricultural development programme will be launched in the irrigated areas by developing or improving the network of agricultural support system. The policy also re-asserts the need of developing small irrigation projects by mobilising users groups or communities.

In the area of land management the policy broadly states that the government will aim at ending dual ownership on land and fix ceiling on land holdings on scientific basis. The policy is silent on the issue of fragmented land holdings or in the need of consolidating small holdings which can have important implications in promoting shallow tubewells.

Appropriate implementation plans or programmes based on this new agricultural policy are still in the making, hence, it will be premature to speculate its impact on the country's agriculture.

III.4.1 Agricultural Inputs, Credit and Price Policies

Availability of agricultural credit and access to market are critically important for improving the performance of irrigated agriculture. The agricultural development programmes of the country till mid-eighties was

The agricultural development programmes of the country till mid-eighties was mainly geared to increase production and less to marketing support. Lack of incentive prices to farmers and high margin of commission taken by the middle men have also dampened farmer's initiatives to invest on farming. In the seventh five year plan (1985-90) the agricultural marketing and pricing policies were explicitly stated for the first time. Since then the agricultural price policy is being increasingly viewed as an incentive for agricultural production. The basic ideas of current agricultural price policy as expressed in the Agricultural Policy 1991 are:

(a) The government will help promote an efficient and expanded agricultural trade sector by involving private and co-operative enterprises. This is gradually expected to correct present distortions and inefficiencies in the free flow of agricultural produce inside the country.

(b) The government will take steps to provide reasonable prices to farmers by fixing minimum support prices for all major food grains and procurement prices for cash crops. For this the government has recently constituted a body called Agricultural Price Commission.

(c) The government will provide technical support to private entrepreneurs or merchants to establish scientifically organised wholesaling establishments in the major centres of the Terai.

On the aspects of inputs supply and inputs pricing the Agricultural Inputs Corporation (AIC), a para-statal organisation created in 1966, plays a major role. AIC imports and procures chemical fertilisers and improved variety seeds and distributes them through private dealers, co-operatives and its own branches. This corporation has virtual monopoly in fertilisers imports, although private sectors are being encouraged by the recent policy to import and distribute fertilisers. Fertilisers supplied by the AIC are highly subsidised by the government (30 to 50 % or Rs 1 000 to 3 000 per tonne) and this has been imposing a heavy financial burden on the government and the corporation.

Recent policy changes in inputs supply and pricing are in the direction of breaking the monopoly of AIC in fertilisers import and distribution and encouraging the involvements of private sector and co-operatives and thereby set a competitive pricing system. However, little progress have been achieved in this direction. Most farmers in the Terai feel that the fertiliser prices are too high at present to encourage them to increase its use. Farmers also complain of the non-availability of fertilisers in time.

The ADB/N is the main agency involved in agricultural financing and credit in Nepal. This bank was established in 1968 under the Agricultural Development Bank Act-2024. The bank has establishments spread all over Nepal. ADB/N's Small Farmers Development Programme (SFDP) has witnessed rapid expansion over the years and has penetrated even at the grass roots level. This bank provides loans for all kinds of agricultural operations such as agricultural production, agri-processing industries, livestock, horticulture and irrigation. ADB/N also is the main vehicle of the government (or DoI) for financing and promoting shallow tubewells among individuals or farmers groups. The bank used to provide 40 to 60 % subsidy (40 % in individual loan and 60 % in group loan through SFDP) in shallow tubewell loans. This loan used to have the maturity period of five years and an interest rate of 15 % per annum was chargeable on such loans. Recently, however, the bank has withdrawn all subsidy in this loan which is expected to have adverse implications for groundwater irrigation development in future.

Agricultural extension services including research and training are administered by the Department of Agriculture (DoA) under the Ministry of Agriculture (MoA/HMG/N). The DoA has network of offices at central, regional, district and at service centre levels. The new agricultural policy emphasises the need of providing all agricultural support services through one unified structure, e.g., mainly through the service centres. As per the policy there will be at least seven service centres in one district whose major functions will be to : demonstrate new farming methods, organising training programmes for leader farmers and extending extension services in the farmer's fields. Available studies, however, show that agricultural extension services, particularly for irrigated agriculture have been very weak in both the Hills and the Terai. Weak agricultural extension training and low personnel incentive systems (salary structure, per diem and travel facilities) have been mainly responsible for this situation.

III.5 Energy Policy

Field observations undertaken for the present study show that most shallow tubewells installed in the Terai are operated by diesel based pumpsets where as deep tubewells are run by electricity driven motors. It was also observed that the electricity for the running of these motors were supplied through the central national grid. Nepal is completely dependent on import for diesel and petroleum products. Although the country has high potential for electricity generation through hydro-power the potential has so far been exploited to a very limited extent. Because of drought and other reasons, the supply of electricity has recently been significantly curtailed throughout the country.

Prices of both sources of energy, electricity as well as diesel, have been increasing over the years. In the past three years prices of diesel and petroleum products have been revised four times and they have increased by 35 to 40 % from the prices of the base year. Similar upward revisions have taken place in the prices of electricity.

The government's new energy policy (see Hydro-power Development Policy-1992, MoWR/HMG/N) is mainly geared to: exploiting the hydro-power potentials of the country, developing alternative sources of energy which can gradually substitute imported fuels and maintaining continuity in traditional source of energy such as fuel wood and bio-mass at the households level. Integrating electricity supply with industrial and irrigation facilities, encouraging rural electrification schemes and connecting them with the central grid, following differential price policy for industrial and family consumption of electricity and improving transmission and distribution efficiency are some other objectives of the new national energy or electricity policy.

To support these policy objectives the concerned government agencies are working to prepare a comprehensive Perspective Energy Plan, establish Alternative Energy Organisation (which will co-ordinate the activities of various agencies researching on alternative sources of energy) and constitute an adequately empowered Public Utilities Commission which will determine the electricity tariffs. A new legislation, the Electricity Act-1992 has also been recently enacted by the government.

In the area of fossil fuel the government's longer term policy goal is to replace them by electricity wherever practicable. Meanwhile, the government is encouraging private entrepreneurs and dealers in distributing diesel and petroleum products inside the country. Importing or procuring petroleum products and fixing prices for them, however, practically, continues to remain a government monopoly which is undertaken by the government run, semi-autonomous, public corporation -- the Nepal Oil Corporation.

The present energy supply scenario (both electricity and diesel) is not likely to change in near future despite the new legislation and the policies. If the government will be able to effectively move in line with the advocative policies and programmes some changes can be expected after eight to ten years time when the capacity of the national grid will significantly improve by the completion of some important hydro-power projects like Kali Gandaki and part of Arun-III.

III.6 Agencies Involved in Groundwater Development

There are mainly two agencies currently responsible for groundwater development: the GWRDB under the DoI/MoWR and the ADB/N. The GWRDB is primarily responsible for defining aquifer characteristics, monitoring water table levels, identifying high groundwater potential areas, setting groundwater development priorities, providing technical guidelines on groundwater development to concerned agencies, drilling deep tubewells, promoting shallow wells in the areas of high aquifer, providing drilling services and handing-over deep tubewells to water users groups after completion. As noted before the role of ADB/N is mainly to provide credit to farmers to enable them to install shallow tubewells. ADB/N also provides some technical support to farmers in selecting well sites and in purchasing and installing pumpsets and well equipment.

Other agencies involved in groundwater development include: the Narayani Zone Irrigation Development Project (NZIDP) implemented by DoI, Janakpur Agricultural Development Project (JADP) under the Department of Agriculture, and Irrigation Management and Water Utilisation Division (IMWUD), DoI/MoWR. The NZIDP is mainly a surface irrigation system, but the project has drilled some (over 30) DTWs in the area between Birganj and Kalaiya and some community shallow tubewells outside the command of the project.

The JADP is involved in developing groundwater in three Terai districts -- Dhanusha, Mahottari and Sarlahi. The IMWUD came into being in the DoI in 1988 after the then existing Farm Irrigation and Water Utilisation Division under the DoA/HMG/N was merged with the Small Irrigation Division of the DoI. IMWUD has two major mandates: to co-ordinate the USAID funded Irrigation Management Project (IMP) and the IDA/ADB/M funded Irrigation Line of Credit and Irrigation Sector Projects (ILC/ISP).

The IMP programme is mainly concerned with systems management research and training and developing procedures and strategies for turning-over agency-owned systems to water users organisations. IMP is currently working to develop training programmes for shallow tubewell owners and irrigators. ILC/ISP is mainly involved in construction and rehabilitation of farmer's irrigation schemes through participatory approaches. ISP has some groundwater development funds which are mainly channelised through the ADB/N shallow tubewell development programme. ILC is also involved in groundwater development in the western Terai districts viz., Dang, Kapilvastu, Nawalparasi, Kailali and Kanchanpur. ILC functions under the DoI's IMWUD and GWRDB. Under ILC project 17 deep tubewells, 46 shallow tubewells and 24 medium tubewells have so far been drilled.

One key feature of ILC groundwater development programme is that it tries to involve water users from the very beginning of project inception.

The Bhairahwa-Lumbini groundwater project under the GWRDB/DoI is one of the major Terai groundwater development projects. Started in 1976, this project is now in its third stage. Fifty one deep tubewells (16 in the first stage, 22 in the second and 13 in the third) with average discharge capacity of 75 l/s and command area of 120 ha per well have so far been installed in BLGWP.

Drilling companies established in the governmental and private sectors and hardware manufacturers, wholesalers and retailers who deal in casing pipes and spare parts are other agencies involved in groundwater development. Reportedly there are mainly four drilling companies active in deep well drilling -- the Nepal Drilling Company, Khetan Group's Drilling Company, NADCO and National Drilling Company.

Limited data are available on the population and working terms of small drilling contractors. Likewise, no research had been undertaken on the numbers and business terms of the spare parts dealers. Except for some training conducted by the Agricultural Credit Training Institute (ACTI) of the ADB/N there is limited institutionalised training facilities on the operation and maintenance of equipment associated with groundwater facility such as pump set or electrically driven motors.

III.7 Current Institutional Development Policies

It is clear from the foregoing description that the government sector, particularly GWRDB/DoI, have major role in groundwater irrigation development. In recent years, however, some re-thinking have started in the apex policy level body of the government on the role and scope of government bodies in the development process. There is a growing realisation that non-governmental organisations (NGOs), private sectors and people in general (through users organisations etc.) should be invited to play more active roles in development and the government should limit its role in those sectors which can not or should not be entrusted to others. At the same time concerns for reform within bureaucracy have also grown in recent days. Two important policy measures for institutional development have recently been announced by the government; Decentralisation policy and recommendations for administrative reforms in the bureaucracy, which will have implications for the organisations dealing with irrigation and agriculture including the groundwater irrigation development.

To regulate its policy on decentralisation the government has recently passed three important laws: the Village Development Committee Act-1991, the Municipality Act-1991 and the District Development Committee Act-1991. The major objectives of these acts are to develop local self-government by decentralising authority, power and resources at the local level, particularly at the district and village committees levels. With these new acts the district development committees (DDCs) and village development committees (VDCs) will play key roles in all development works initiated at the local levels including groundwater irrigation development.

These decentralisation acts provide authority to local bodies to impose levies and taxes from appropriate local sources and utilise them for development works. These acts also dwell on the procedures of mobilising community participation in construction and maintenance of community infrastructures such as irrigation and drinking water.

To initiate bureaucratic reform, in 1992 a high powered Administrative Reform Commission was set up. This commission's recommendations have already begun to be implemented in a phased way. Major recommendations cover the following areas: delineating the sphere and scope of government bureaucracy operations and non-governmental and private institutions, bringing uniformity in civil service regulations by adopting a unified civil service code, trimming bureaucracy by cutting present staff levels by at least 25 %, decentralising authority and resources at the service delivery level, simplifying government office procedures and performance monitoring and evaluation.

These recommendations of administrative reform commission will have implications for all government bodies at all levels of operation including GWRDB or DoI. In the process of implementing these recommendations a number of senior chief executives of the DoI and GWRDB have been recently retrenched. Senior positions in DoI and GWRDB have now been occupied by a new group of engineers whose leadership style would influence the future course of groundwater irrigation development. Other implications of the Administrative Reform Commission's Report is that it has opened up inter-institutional competition in service delivery and new non-governmental organisations and private sector agencies could inter in competition with the governmental bodies in developing small irrigation services.

III.8 Summary and Implications

The prime purpose of this paper was to examine recent changes in relevant government policies and institutions influencing groundwater development.

Major findings of the study are following:

(a) The government's role in the construction, operation and maintenance of irrigation facilities will be gradually decreased in future by increasing participation of organised water users.

(b) The water users association will be organised as legal bodies which will eventually take over all irrigation systems including group owned deep tubewells.

(c) Such legally constituted water users associations will fully participate in the planning design and implementation of the irrigation facilities e.g.,community owned shallow or deep tubewells, bear a certain portion of the capital cost of the project and entirely take-up operation and maintenance responsibilities.

(d) Private irrigation systems (of less than 25 ha. in the Terai and 10 ha. in the hills) will be promoted with more emphasis.

(e) Environmental and sociological considerations will be given due weight in planning and utilising all kinds of irrigation systems.

(f) Emphasis on conjunctive use of surface and groundwater sources will be placed wherever feasible.

(g) Involvement of NGOs and private sectors will be encouraged in all areas.

(h) Bureaucratic authority and resources will be decentralised at the service delivery levels.

(i) Local bodies will be authorised to play major roles in all development works of local nature including irrigation.

One important finding of this review is that so far a separate legislation governing groundwater irrigation development does not exist in Nepal. More effective utilisation of groundwater irrigation may call for a separate legal arrangement for this source of irrigation development. The contents of such legislations would be spelled by conducting a more in-depth study on the issues, rights and obligations of the groundwater irrigators and water buyers.

Recent policy changes in ADB/N's lending operations on shallow tubewells which curtailed the 40 % subsidy previously been given to the farmers, could adversely affect the development of shallow tubewells in future. Appropriate strategy would have been to gradually decrease the proportion of subsidies and eventually, withdraw them in full in course of time.

Institutional review undertaken in this paper indicates that there are practically no institutions presently existing in Nepal which provide training on the operation and maintenance of equipment associated with groundwater facility such as pump set and motor. Incentives for drilling contractors, particularly, for small drilling groups also appear to be low. Increasing price of energy and irregularity of supply -- the situation prevailing at present could limit farmers investment in groundwater irrigation.